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**Manitoba
Energy and Mines**



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**A PROJECT SUPPORTED BY THE MANITOBA/CANADA CONSERVATION
AND RENEWABLE ENERGY DEMONSTRATION PROGRAM**

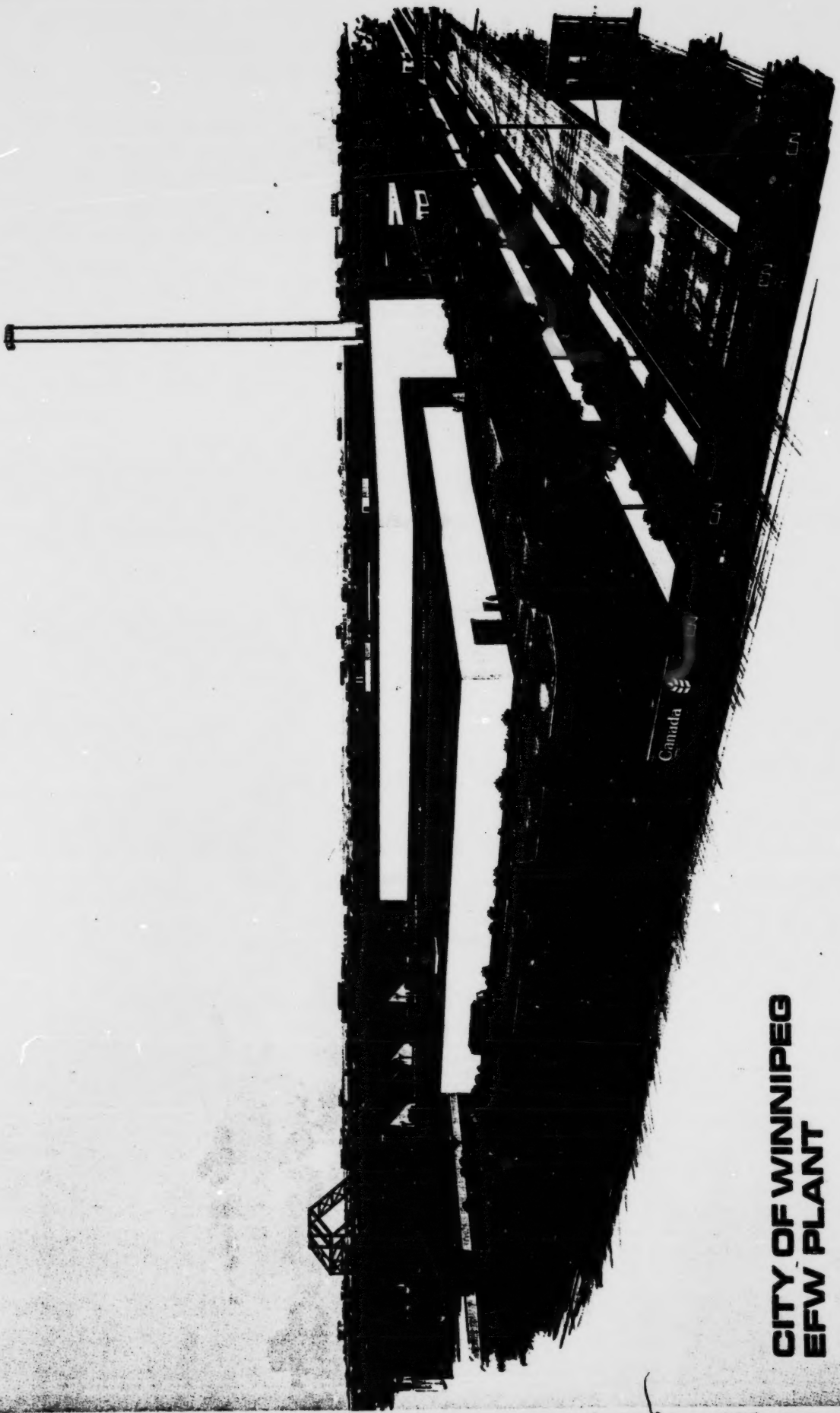
**STUDY INTO THE ECONOMIC
VIABILITY OF DISTRICT
HEATING FOR THE
CENTRAL AREA OF THE
CITY OF WINNIPEG**

**VOLUME I
PART I — SUMMARY**

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**CITY OF WINNIPEG
EFW PLANT**



MANITOBA/CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources — oil and natural gas — are becoming less accessible and more costly. However, Canada is well-endowed with renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of Manitoba and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement which was signed May 9, 1980 and terminated March 31, 1984. The Agreement was dedicated to the development and demonstration of conservation and renewable energy technologies. Equally cost-shared by the provincial and federal governments, the program had a total budget of \$18-million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within Manitoba.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

VOLUME I

PART 1 - SUMMARY

PART 1

SUMMARY

TABLE OF CONTENTS

	<u>Page</u>
EXECUTIVE SUMMARY	i-xii
1.1 INTRODUCTION	1-1
1.1.1 Background	1-1
1.1.2 Phase II	1-2
1.1.3 Report Arrangement	1-3
1.2 MARKET PROSPECTS	1-4
1.2.1 Methodology	1-4
1.2.2 Customer Decision Factors	1-5
1.2.3 Market Location and Size	1-8
1.2.4 Probable Demand for EFW Plant Heat Energy	1-8
1.2.5 Price Levels	1-10
1.2.6 Price Structure	1-11
1.2.7 Contracts and Negotiations	1-11
1.2.8 Other Factors	1-12
1.2.9 Recommendations	1-12
1.3 SOLID WASTE AND OTHER FUELS	1-14
1.3.1 Municipal Solid Waste	1-14
1.3.1.1 Quantities	1-14
1.3.1.2 Heating Value	1-15
1.3.1.3 System Costs	1-16
1.3.1.4 Land Requirements	1-18
1.3.2 Auxiliary Fuels	1-18
1.3.3 Special Wastes	1-19

	<u>Page</u>
1.4 EFW PLANT	1-20
1.4.1 Conceptual Design Considerations	1-20
1.4.2 Selected Plant Description	1-21
1.4.2.1 Plant Size	1-21
1.4.2.2 Solid Waste Handling	1-22
1.4.2.3 Incineration	1-22
1.4.3 Flue Gas Cleaning Process	1-24
1.4.4 Facilities at Amy Street	1-25
1.4.5 Cost Estimates	1-25
1.4.5.1 Capital Cost	1-25
1.4.5.2 Operating Costs	1-26
1.5 DISTRIBUTION NETWORK	1-27
1.5.1 Heat Load Definition	1-27
1.5.2 Distribution Configuration	1-28
1.5.3 Customer Connections	1-30
1.5.4 Existing Distribution Network	1-31
1.5.5 Cost Estimates	1-31
1.6 ENVIRONMENTAL AND SOCIO-ECONOMIC CONSIDERATIONS	1-33
1.6.1 Environmental Considerations	1-33
1.6.1.1 Air Environment	1-34
1.6.1.2 Water Environment	1-37
1.6.1.3 Soil Environment	1-38
1.6.2 Socio-Economic Impacts	1-38
1.6.2.1 Short-Term Effects	1-39
1.6.2.2 Long-Term Effects	1-39
1.6.2.3 Other Benefits	1-40
1.7 SITE SELECTION	1-41
1.7.1 Methodology	1-41
1.7.2 Candidate Sites	1-42
1.7.3 Site Selection Criteria	1-43
1.7.4 Criteria Weighting	1-44
1.7.5 Site Scores	1-45
1.7.6 Site Specific Costs	1-45
1.7.7 Selection Process	1-46

	<u>Page</u>
1.8 ECONOMIC ANALYSIS	1-48
1.8.1 Methodology	1-48
1.8.2 Economics at Study Milestones	1-50
1.8.3 Final Economic Analysis	1-52
1.8.4 Project Financing and Ownership	1-53
1.8.5 Economic Viability - Scenario with Inflation Included	1-54
1.9 IMPLEMENTATION PLAN	1-56
1.9.1 Stage I - City of Winnipeg Decision and the Identification of a Proponent	1-57
1.9.2 Stage II - Proponent Selection of an Ownership Structure and the Design of a Corresponding Implementation Effort	1-57
1.9.3 Stage III - Proponent Implementation Activities if Public Ownership Selected	1-59
1.9.4 Stage IV - Proponent Implementation Activities if Private Ownership Selected	1-60
1.9.5 Stage V - Implementation Activities of the Owner (Public or Private) once the Final Decision to Construct is Made	1-61
1.9.6 Stage VI - Construction Activities	1-62
1.9.7 Summary	1-62

PART I
SUMMARY
LIST OF FIGURES

<u>Figure No.</u>	<u>Title</u>	<u>Following Page</u>
1.1	Monthly Energy Balance - 1990	iii
1.2	Sensitivity Analysis	viii
1.3	Yearly Project Level Cash Flows	ix
1.4	Implementation Schedule Public Ownership - Fast Track	x
1.5	Average Unit Cost of Steam Vs. Time	1-9
1.6	Active Landfill Sites	1-15
1.7	Landfill Quantities with EFW Based Disposal System	1-17
1.8	EFW Plant - Conceptual Design Considerations	1-20
1.9	1500 t/d EFW Plant Longitudinal Section	1-21
1.10	Steam Distribution Network Schematic	1-27
1.11	Candidate Sites	1-41
1.12	Site Selection Site Ratings vs. Site Specific Costs	1-45
1.13	Preferred Plant Site: Mill Street	1-46
1.14	Sensitivity Analysis	1-52
1.15	Yearly Project Level Cash Flows	1-55
1.16	Energy from Waste Implementation Plan Stages	1-56
1.17	Implementation Schedule Public "Fast-Track" vs. Private Sequential	1-59

PART I

SUMMARY

LIST OF TABLES

<u>Table No.</u>	<u>Title</u>	<u>Following Page</u>
1.1	District Heat Sales Total Revenue and Volume Forecasts	1-3
1.2	Revenues and Volume Forecast	1-8
1.3	Haul and Landfilling Costs	1-16
1.4	Summary of Heat Loads (1990)	1-26
1.5	Summary of Maximum Ground Level Contaminant Concentrations from Three EFW Plant Sizes	1-34
1.6	Site Selection Matrix (Summary)	1-44
1.7	Summary of Illustrative Financing Scenario	1-55

EXECUTIVE SUMMARY

General

This study of The Economic Viability of District Heating for the Central Area of the City of Winnipeg has established that a viable system is possible. The recommended arrangement is a three unit, solid waste fired, energy from waste incineration facility located at a Mill Street site in the downtown area. The estimated construction cost is \$108 million (1983\$). Significant benefits can accrue to the City of Winnipeg from such a facility.

The City of Winnipeg currently operates a district heating system in downtown Winnipeg. Steam is generated in a coal burning plant at Amy Street. The system incurs significant operating deficits and is under a Clean Environment Commission order to reduce pollution. The steam plant and steam distribution system requires major upgrading at a cost of approximately \$20 million. This expenditure cannot be recovered and a decision on the existing plant's future is required. This was one of the reasons that precipitated the present study of an expanded district heating system using municipal solid waste as a fuel.

The study of the expanded system addressed viability through the evaluation of key components such as:

- . Markets for the energy and the selling price.
- . Fuels for the plant with primary emphasis on municipal solid wastes. Auxiliary fuel availability and prices were also investigated.
- . The role an Energy from Waste (EFW) plant could play in the disposal of special wastes.
- . The design and cost estimation of the EFW plant to match identified markets and available solid wastes.
- . The heat transport medium and its distribution to prospective customers.
- . Assessment of environmental concerns and their mitigation.
- . Review of the socio-economic effects of the completed system.
- . Identification of a suitable site for the facility.
- . The economics of the system.
- . Implementation of the recommended system.

Market and Price

In the evaluation of markets, all heat loads within a reasonable distance of the downtown were quantified. A market analysis by personal interview was performed for all of the larger potential loads. From this review of the market, a projected sales volume for steam was established for each year of the EFW plant's 30-year life. The initial market is expected to be approximately 1,393,655 gigajoules per annum (GJ/a) in 1990. This consists of:

	<u>GJ/a</u>
Existing Any Street Customers	422,000
New Downtown Customers	365,030
Health Sciences Centre	<u>606,625</u>
	1,393,655

This load is projected to grow to 1,564,565 GJ/a by 2019.

An analysis of the selling price of the steam was carried out. It was concluded that in order to be attractive to prospective customers, steam sold by the system would have to be priced below competitive heat sources. The main competitors were identified as natural gas and electricity, with electricity projected to drive pricing during most of the project's life. Analysis indicated that for most customer loads, natural gas and electricity energy prices will be very nearly equal in 1990 when the system starts operation. As electricity prices are projected to increase at a slower rate than natural gas, in subsequent years, electricity will provide the main competition for steam from a district heating system.

The price for steam was set below that from competing energy sources (on an energy equivalent basis) and provided one of the inputs to the economic analysis of the District Heating system.

The analysis used to establish the price for steam consisted of an avoided cost analysis in which the cost to the customer for conversion to the least expensive alternative fuel source was determined. Prices (in 1983 dollars) are projected to decrease in the early years of the project and then to increase over time. This increase is partially related to a "discount" provision, to attract customers to the system initially, which will be discontinued in later years.

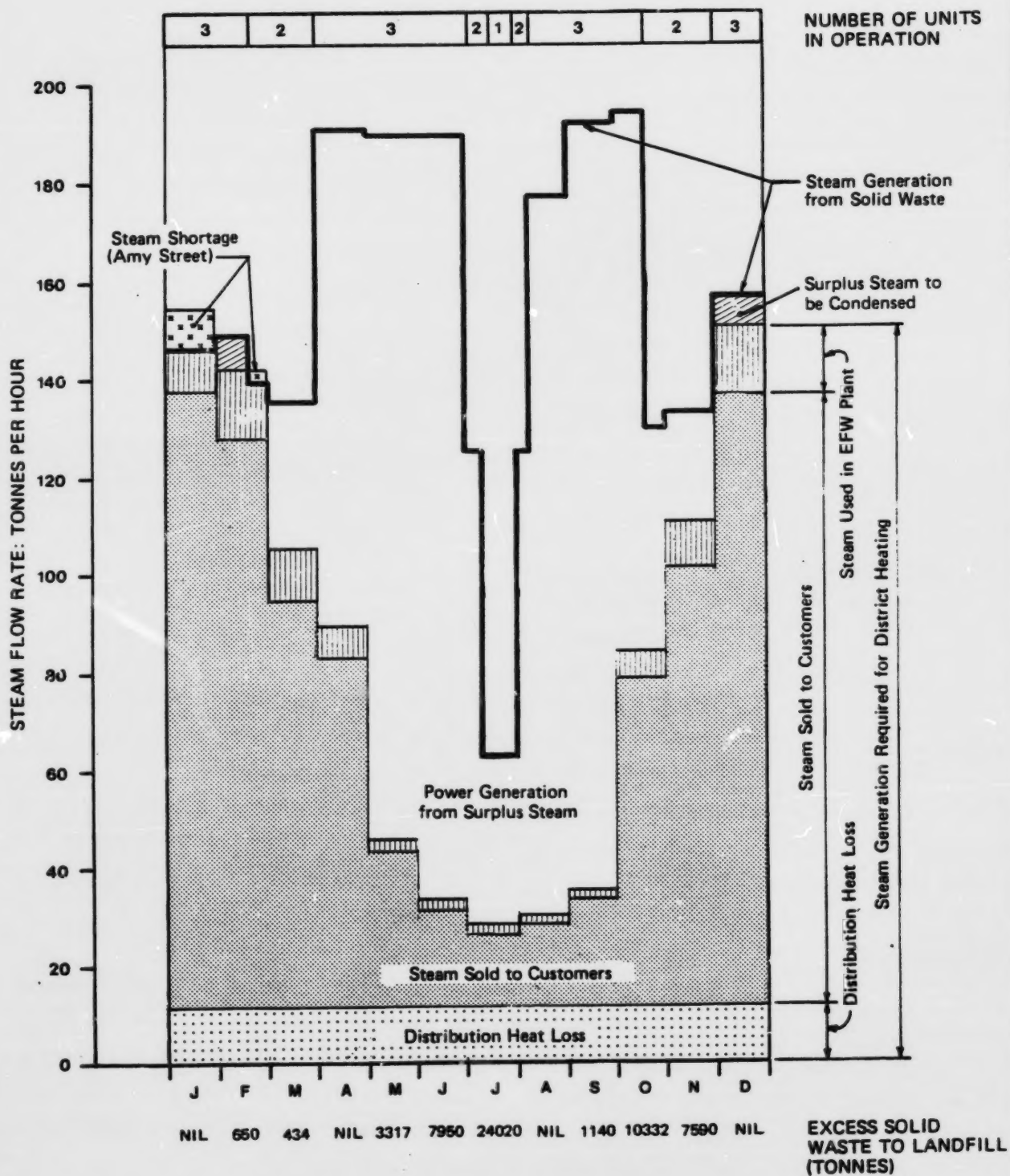
Fuels

The primary fuel for the EFW plant will be municipal solid waste (MSW). The quantity of MSW available to the plant was established and projections prepared over the life of the facility. The generation of waste follows a monthly pattern and this was established. These projections were used as input to the sizing of the EFW plant.

The burning of MSW reduces the volume of material to be landfilled and a plant located in downtown Winnipeg will reduce the costs of hauling the waste. These savings are estimated at \$3.2M (1983) in 1990 and they increase in later years. As these are "avoided costs" as a result of the project, they have been considered as revenue to the project and are carried in the form of tipping fees charged by the EFW plant in the economic analysis.

As peak winter heat demand in the early years of the project life cannot be met by MSW alone, auxiliary fuels were studied to determine their price and availability. These prices were used in the economic analysis to determine the cost of providing winter peak requirements.

The Province of Manitoba is considering the establishment of a hazardous waste disposal facility, consequently no role is envisioned for the EFW plant in this regard. The revenue available from disposal of less hazardous special wastes is minor and the equipment required for handling them would add to the capital cost of the facility. At this stage of planning for the facility, no provision is included for handling special wastes.



CITY OF WINNIPEG – DISTRICT HEATING STUDY
MONTHLY ENERGY BALANCE – 1990

FIGURE 1.1

Energy from Waste Plant

Many combinations of technology options, heating loads, plant sizes and sites were investigated in arriving at the final EFW plant configuration. The selected plant consists of three units of the mass burning type each capable of handling 500 tonnes per day of MSW. The incinerator/boilers will generate steam at 3000 kPa (420 psig) and 320°C (608°F). Each unit will operate 7500 hours per year and is out of service for scheduled cleaning and maintenance for 1260 hours per year. The proposed plant will burn 89% of the incinerable solid waste collected in Winnipeg in 1990 and 69% in the year 2019 assuming no plant expansion in the interim period. The steam generated will be supplied to the district heating network. In warm weather, excess steam will be available beyond the heat demand; the surplus will be used for generation of electricity utilizing the turbo-generators in the existing Amy Street steam plant. This electricity will be sold to the Manitoba Hydro/Winnipeg Hydro system at an estimated price of 1.2 cents per kilowatt hour.

The technology chosen for the plant is a mature technology which has been applied in many installations in North America and Europe. Mass burning incinerators burn MSW "as-received" on grates, thereby avoiding the fuel preparation steps which cause most of the problems in plants using suspension firing.

Additional steam, which will be required to meet peak demands in the coldest winter months, will be supplied by an existing boiler in the Amy Street plant which will be converted to gas firing. A graph of month-to-month variations in plant and system operations for the year 1990 is shown in Figure 1.1. As a part of future customer contracts, it may be possible to arrange to utilize some of the steam generators presently serving larger customer facilities for peaking service.

Flue gas from the incinerator units will pass through a flue gas cleaning system and be discharged through a 100 meter high stack. Emissions will be also below the limits set by all regulations presently in force and below the most severe requirements for any regulations presently under consideration.

In the conceptual layout for the plant, space is available on the site for installation of a fourth unit should this prove to be desirable in the future.

Distribution Network

Steam was chosen as the heat carrier for two reasons:

- . The majority of prospective new loads require steam for their systems.
- . The existing downtown district heating system utilizes steam.

Based on the customers identified in the market studies, extensions to the existing steam distribution network were designed. The extensions are 6.8 km in length and are estimated to cost \$11.5 M (1983). As customers on the existing district heating network are to be serviced from the new system, the existing network will require a major rehabilitation which is estimated to cost \$9.0M (1983). Although condensate is not presently recovered from existing district heat customers, for some of the larger new loads it is proposed that condensate be returned to the EFW plant. The new steam supply lines will be contained in precast concrete conduits buried below the Winnipeg street system. Where condensate return lines are installed, they will be outside the conduit in the same trench.

Environmental Considerations

Potential environmental concerns associated with the operation of a 1500 tonne per day EFW plant in downtown Winnipeg were examined. It was concluded that such a facility can be operated with no significant adverse impact on the environment. The main focus for environmental concerns is likely to be stack discharges to the air environment. As the plant will be equipped with an efficient flue gas cleaning system, all present regulations and the guidelines for future regulations presently being considered can be met.

Condensation of the steam used to generate electricity at Amy Street will require cooling water from the Red River. Thermal discharge to the river has been analyzed and the average temperature rise in the river (under low flow conditions) slightly exceeds the 1°C outlined in the Surface Water Quality Objectives which were proposed in 1981. The proposed objectives are presently under review by the Manitoba Environmental Management Division, and consequently no definitive assessment can be made of conformance. This factor will require further study during environmental impact assessments and could require limiting generation when sensitive periods for aquatic life coincide with low flow conditions. This is expected to occur infrequently and consequently is not likely to seriously impact project economics.

The ash from incineration will be disposed through landfilling. This relatively sterile ash will present fewer environmental problems than the disposal of MSW without incineration as presently practised.

MSW will be delivered to the plant in closed vehicles and will be unloaded in an enclosed tipping hall. Incremental traffic will be approximately 2% of present traffic volumes and consequently will not have a significant impact on adjacent streets.

Socio-Economic Considerations

Benefits of the project to the City of Winnipeg include recovery of valuable energy from waste materials, reduced land consumption by landfills required to dispose of City refuse, savings in refuse haulage and landfill operating costs, extension of the useful life of existing landfills and provision of more lead time for future landfill planning. The project also has the potential to provide important support to the vitality of central Winnipeg through lower cost energy supplies and will be a generator of employment during the construction and operating phases. Through sensitive architectural treatment of the building, the EFW Plant can enhance the urban environment, including upgrading of the downtown riverbanks. In addition to the plant itself, with conversion of the Amy Street plant to gas firing, the unsightly coal piles on the riverbank, and excessive particulate emissions will be eliminated.

Site Selection

The search for a suitable site for the EFW plant consisted of the identification of eight candidate sites, assessment and rating of these sites against sixteen environmental and community impact criteria, weighting of the criteria by a panel independent from the study and scoring of the sites based on ratings and weightings. Once scores were established, site specific costs for each site/scenario were established and a plot of "scores" versus cost was utilized to establish the most desirable site. The Mill Street site was chosen as the preferred site with Grace Street as the alternative. Mill Street is located near the downtown market for steam and is on land which is largely City owned. This site was judged to strike the best balance between environmental/public acceptability, and site specific cost.

Estimated Costs

Estimated construction costs for the facility are summarized below:

<u>Item</u>	<u>\$000's (1983)</u>
Land and site improvements	\$ 3,070
Building	14,464
Equipment	62,084
Sales Tax, Engineering	16,240
Commissioning and Contingency	
New Distribution System	11,346
Amy Street Modifications	<u>880</u>
TOTAL TO 1990	\$108,084

These costs could be spread over a four to five year period on approval to proceed with the project. In addition to these costs, refurbishment of the existing district heating network has been estimated on the basis that it would occur over the first 10 years that the system is in operation at a total cost of \$9.0M (1983). Customer connections for those that join the system after the system is operational are estimated at \$1.65M (1983), spread over the project life.

Operating Revenues and Costs

Project cash operating revenues and costs have been determined over the project life. These revenues and costs for selected years are displayed below:

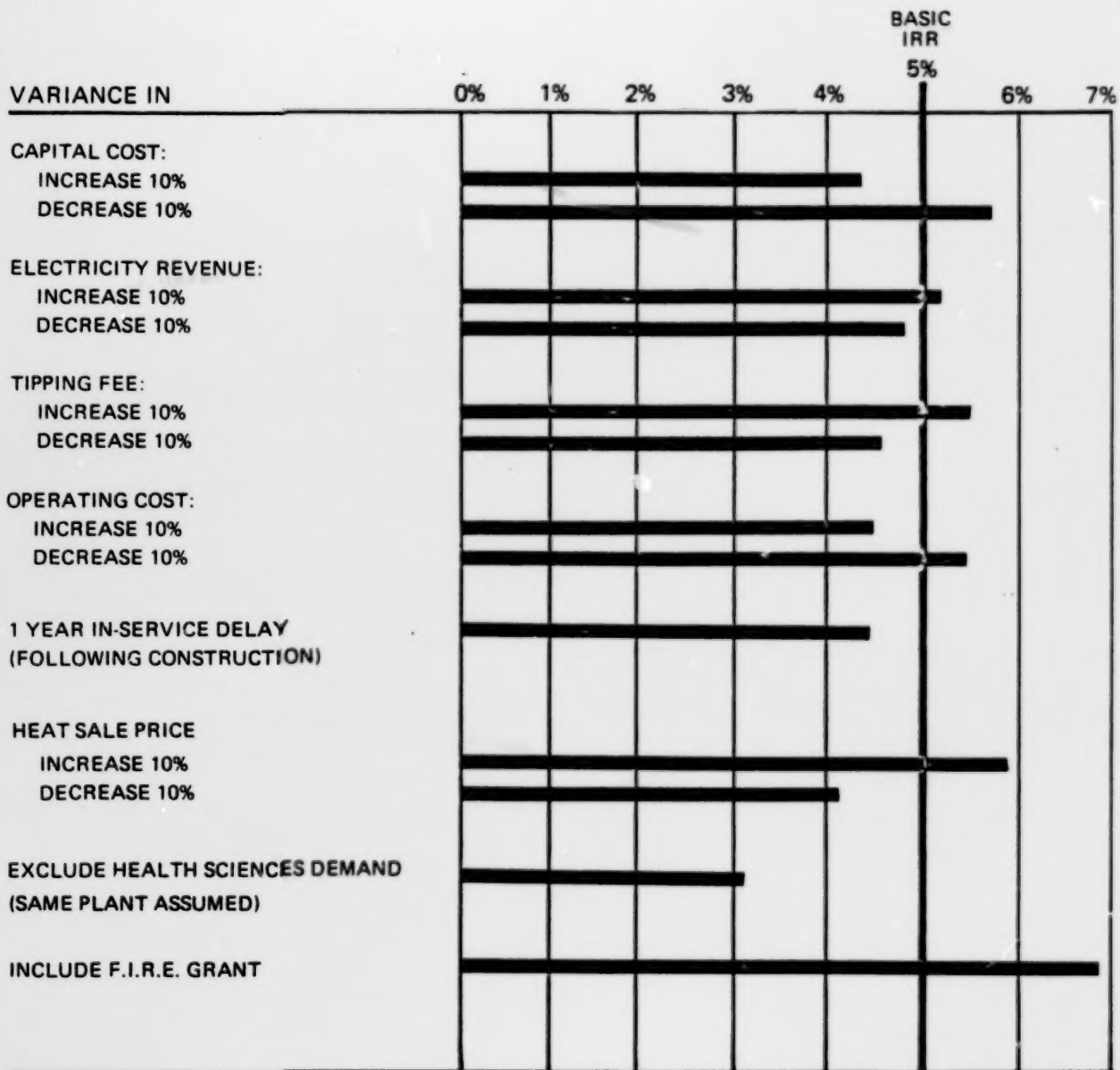
\$000's - Constant 1983
(cost of capital not included)

	Year						
	1991	1996	2001	2006	2011	2016	2019
Revenue							
Steam revenue	9213	8128	8366	8650	8773	8834	8896
Tipping revenue	2970	3102	3019	3087	3280	3471	3471
Electricity revenue	1451	1525	1599	1697	1771	1894	1919
Total Revenue	13634	12755	12984	13434	13824	14199	14286
Costs							
EFW plant labour	3506	3506	3506	3506	3506	3506	3506
Start-up fuel	4	5	5	5	5	5	5
Electricity purchased	487	385	395	411	411	411	411
Amy St. plant	600	600	600	600	600	600	600
Peaking fuel	96	98	65	-	-	-	-
District heating network	620	620	670	613	613	613	613
Other	452	457	463	466	468	469	471
Total Costs	5765	5671	5704	5601	5603	5604	5606
Project Net Cash	7869	7084	7280	7833	8221	8595	8680

Economic Analysis

Project economics were assessed based on a discounted cash flow analysis. The analyses were continually updated during the course of the study as refined data became available. Based on these analyses, the project is economically viable. The analysis was a stratified analysis to project cash flow which affected the facility itself, Winnipeg Hydro, the City of Winnipeg, the Province of Manitoba, the Federal Government and society at large.

PROJECT LEVEL IRR



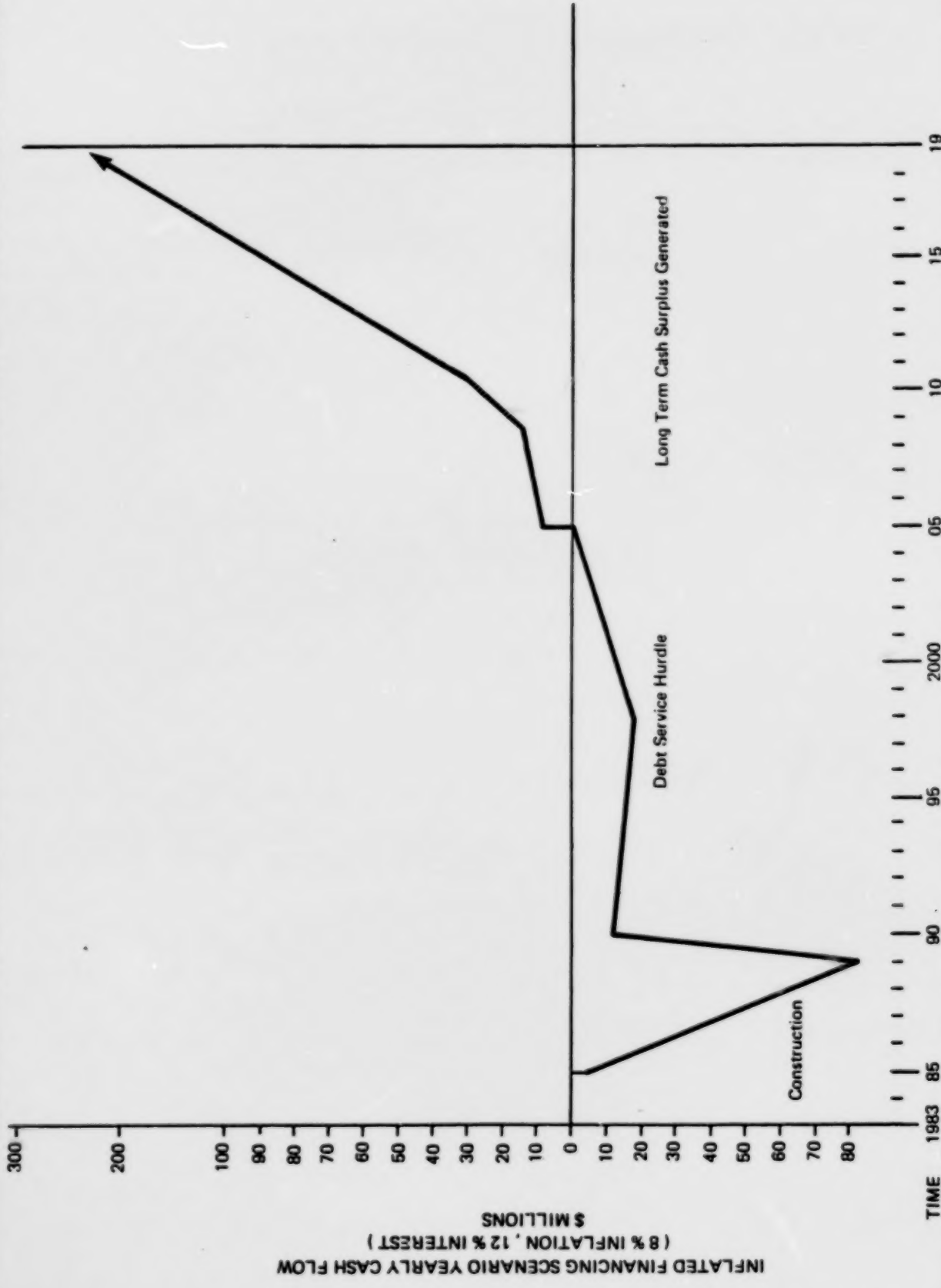
The Government of Canada presently operates a grant program entitled "The Forest Industry Renewable Energy Program" (FIRE). This program provides a grant to projects which utilize renewable resources and amounting to 20 percent of plant, equipment and distribution system costs. This project qualifies as it would utilize municipal waste as an energy form in substitution of purchased energy. The deadline for application for this grant is March 31, 1986. For this project, the grant has been estimated at approximately \$21.5 million by the plant's in-service date.

The real (not inflated) internal rate of return (IRR) for the recommended scenario, at the various levels of analysis are as follows:

<u>Level</u>	<u>IRR (no grants)</u>	<u>IRR (with FIRE Grant)</u>
Project Level	5.04	6.86
Winnipeg Hydro		10.35
City of Winnipeg		10.39
Province of Manitoba		10.45
Federal Government		10.46
Society		11.92

As this indicates, the project provides a real (not inflated) return of 5 percent at the project level. Including the Federal FIRE grant this increases to 6.9 percent. The actual rate of return will be greater than the above figures by the amount of inflation.

A sensitivity analysis to variances in input data was performed to determine the impact these changes would have on project economics. The results of this analysis are depicted in Figure 1.2. It can be seen that while variations in steam revenues and capital costs have the greatest impact on project returns, the project is not radically sensitive to moderate changes in any one variable.



CITY OF WINNIPEG — DISTRICT HEATING STUDY
YEARLY PROJECT LEVEL CASH FLOWS

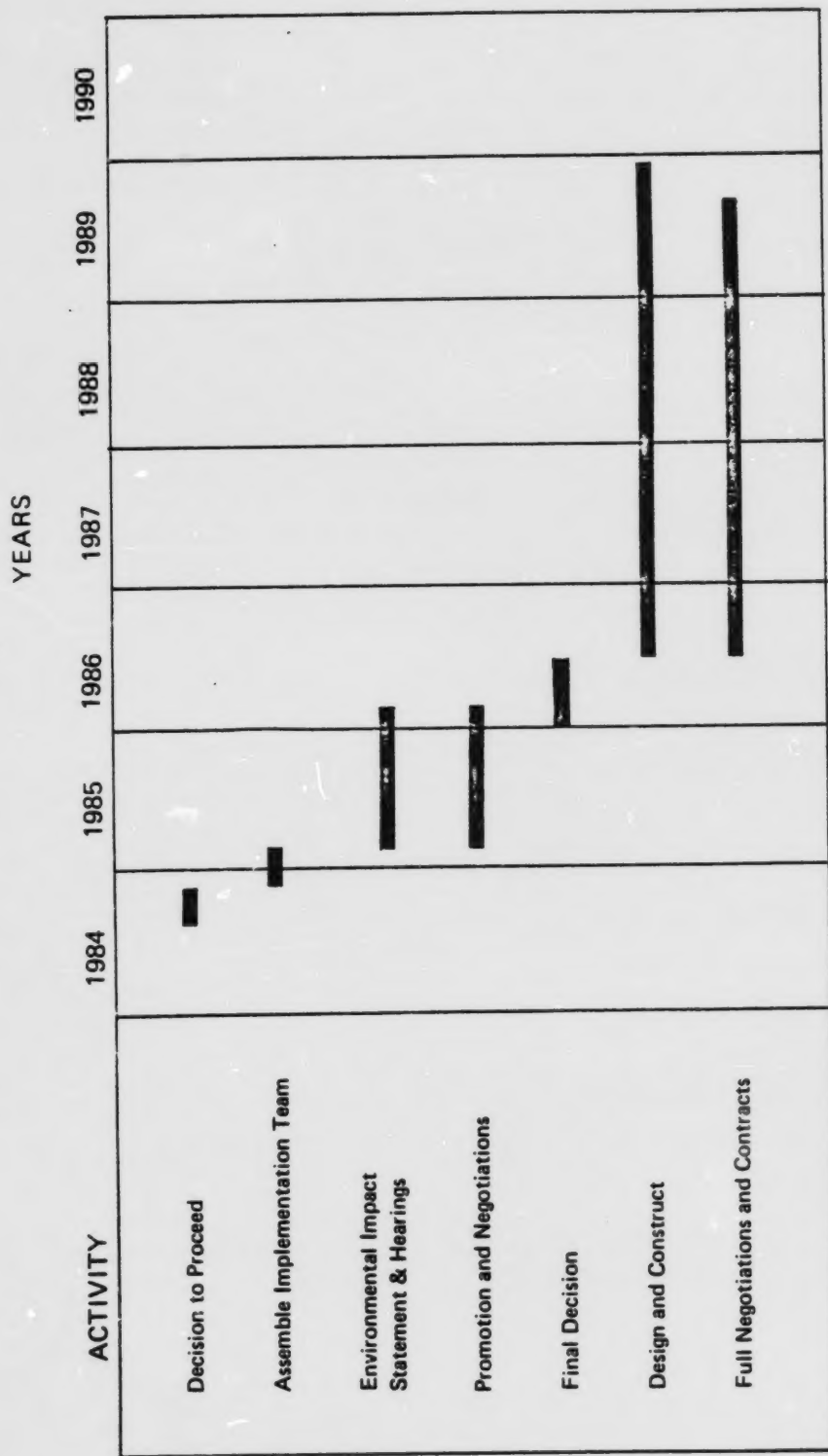
For illustrative purposes, an economic analysis was performed under an assumption of 8% inflation and 12% interest. The analysis showed that construction costs, in inflated dollars and including interest during construction, would be approximately \$180 million. Total debt outstanding, in inflated dollars, will peak approximately 13 years after plant opening at \$300 million. The facility will fully pay for itself after 25 years of operation and have more than 1 billion inflated dollars on hand at the end of the 30-year operating period. The project yearly cash flow for this scenario is illustrated in Figure 1.3.

As a part of the economic study, financing and ownership issues were reviewed. Due to the low returns at the project level and high perceived risks, the project is not deemed to be sufficiently attractive to entice private sector investors. This was confirmed through interviews with several potential private investors. As the majority of the indirect benefits of the project accrue to the City of Winnipeg, it has been concluded that the most likely ownership scenario is one in which the system is operated as a municipal utility and funded through municipal debt. At this level, there is a significant return on investment.

Implementation

The implementation of this project from receipt of this report to its start-up and operation will require careful planning. The consultant has studied the required sequence of events and has based this report on what can be described as an optimistic time scenario. This scenario assumes a strong desire to proceed quickly to put the system into operation. Under this scenario, the more significant events are as follows:

- . Decision to Proceed - This decision will be taken after a thorough review of this report - Month 3.
- . Assemble Implementation Team - A team will be required whose mandate will be to review the project development, plan its completion and implement the plans - Month 6.



CITY OF WINNIPEG - DISTRICT HEATING STUDY
IMPLEMENTATION SCHEDULE
PUBLIC OWNERSHIP - FAST TRACK

FIGURE 1.4

- Environmental Impact Statement and Hearings - For a project of this type, this work may be necessary to obtain Clean Environment Commission approval and to inform the public about aspects where they may have concerns - Month 18.
- Promotion and Negotiations - In parallel with the environmental work, the project concept will be more fully developed and promoted with potential customers, government commitments will be put in place, preliminary contract negotiations will be begun and agreement in principle for purchase of electricity generated at Amy Street will be obtained from Manitoba Hydro/Winnipeg Hydro. Legal ramifications will be studied, contract details delineated and financing arrangements studied - Month 18.
- Final Go/No Go Decision - With the information obtained from the above steps an updated economic analysis will be performed, the project definition refined as necessary and a decision made to either proceed with the project or to abandon it - Month 22.
- Design and Construct - At this point, contracts will be put in place to have the final facility design proceed, equipment will be pretendered and construction will be undertaken. Equipment and system commissioning and start-up will be completed - Month 64.
- Full Negotiations and Contracts - In parallel with the previous design and construct activity, full negotiations will be carried out with all affected parties and contracts will be put in place - Month 60.

The entire implementation program is expected to require 64 months if all activities proceed smoothly with no delays between steps. Based on submission of this report in August, 1984, this will result in an operational facility in December of 1989. This means that heat could be provided to customers in the winter of 1989-90. This public ownership "fast-track" scenario is depicted in Figure 1.4.

The above scenario requires decisions to be made quickly and the strong will of the proponent to proceed to completion. Under an alternate more cautious scenario where activities are scheduled sequentially rather than in parallel and where long periods are allowed for interim assessments and decision-making, the total elapsed time might increase by as much as two years or more.

In summary, an economically viable, environmentally acceptable Energy from Waste District Heating System is possible for the City of Winnipeg. The system is likely to be a municipal utility and could be in full operation by the winter of 1989-90.

Footnote:

For complete information on any study aspect, the reader is referred to the summaries which follow in this Part 1 - Summary, or to subsequent report volumes as follows:

VOLUME II - PART 2 - MARKET PROSPECTS

- PART 3 - SOLID WASTE AND OTHER FUELS

VOLUME III - PART 4 - EFW PLANT

- PART 5 - DISTRIBUTION NETWORK

VOLUME IV - PART 6 - ENVIRONMENTAL AND SOCIO-ECONOMIC CONSIDERATIONS

- PART 7 - SITE SELECTION

VOLUME V - PART 8 - ECONOMIC ANALYSIS

- PART 9 - IMPLEMENTATION CONSIDERATIONS

RÉSUMÉ

Généralités

La présente étude de viabilité économique d'un système zonal de chauffage pour le centre de la Ville de Winnipeg a permis de déterminer la validité d'un tel projet qui comprendrait une installation à trois unités fonctionnant à l'aide de l'énergie produite par l'incinération de déchets solides, située sur la rue Mill dans le centre-ville. Le coût de la construction est évalué à 108 millions de dollars (\$ 1983). La Ville de Winnipeg tirerait des avantages importants de l'exploitation d'une telle installation.

À l'heure actuelle, la Ville de Winnipeg exploite un système de chauffage zonal dans le centre-ville. La vapeur qui est utilisée est produite dans une centrale à charbon se trouvant sur la rue Amy. En plus que de connaître des déficits assez importants, cette installation doit, conformément à une décision de la Commission de protection de l'environnement, réduire la pollution qu'elle provoque. Le système de production et de distribution doit être amélioré, opération qui coûterait environ 20 millions de dollars. Une telle dépense ne peut être recouvrée et une décision doit être prise quant à l'avenir de cette installation. Cette question est l'une des raisons de la mise sur pied de la présente étude d'un système de chauffage zonal utilisant comme combustible les déchets solides municipaux.

L'étude du système a porté sur l'évaluation des composantes essentielles suivantes :

- . Les marchés de l'énergie produite et le prix de vente.
- . Les combustibles utilisés, de préférence les déchets solides municipaux.
- . La disponibilité de combustibles auxiliaires et les prix correspondant ont aussi fait l'objet d'une recherche.
- . Le rôle qu'une installation fonctionnant à l'énergie produite par des déchets (EPD) pourrait jouer sur le plan de l'élimination des déchets spéciaux.
- . La conception et l'évaluation du coût d'une telle installation pouvant répondre aux marchés identifiés et utiliser les déchets solides.

- Le moyen de transport de la chaleur et sa distribution aux clients éventuels.
- L'évaluation des problèmes environnementaux et leur atténuation.
- L'analyse des conséquences socio-économiques de la mise en place du système.
- L'identification d'un site se prêtant à une telle opération.
- L'aspect économique du système.
- La mise en oeuvre du système recommandé.

Marchés et prix

Dans le cadre de l'évaluation des marchés, tous les besoins d'énergie provenant de quartiers situés à une distance raisonnable du centre-ville ont été quantifiés. Une analyse de marché a été faite sous la forme d'entrevues personnelles dans le cas de tous les besoins éventuels plus importants. Cette analyse a permis d'établir des prévisions relatives au volume des ventes de vapeur pour chacune des 30 années de la vie de l'installation prévue. Le marché initial est de l'ordre de 1 393 655 gigajoules par an (Gj/an) en 1990. Il se décompose comme suit :

	<u>GJ/an</u>
Consommateurs actuels de l'installation de la rue Amy	422 000
Nouveaux consommateurs au centre-ville	365 030
Centre des sciences médicales	<u>606 625</u>
	1 393 655

Cette production devrait s'accroître jusqu'à 1 564 565 GJ/an en 2019.

On a aussi procédé à l'analyse du prix de vente de la vapeur. Pour présenter un intérêt aux yeux des clients éventuels, elle devrait se vendre en-dessous du prix des autres sources de chaleur. Les principaux concurrents sont le gaz naturel et l'électricité, cette dernière devant, selon les prévisions, être la base de l'établissement des prix pendant presque toute la durée de vie du projet. L'analyse a montré que dans le cas de la plupart des besoins identifiés, les prix du gaz naturel et de l'électricité seront à peu près égaux en 1990, lorsque l'installation entrera en exploitation. Comme il est prévu que le prix de l'électricité augmente plus lentement que celui du gaz

naturel, ce sera donc l'électricité qui, par la suite, concurrencera le plus la vapeur produite par un système de chauffage zonal.

Le prix de la vapeur a été établi à un niveau inférieur à celui des autres sources d'énergie concurrentielles (sur une base d'équivalence de l'énergie) et c'est l'un des facteurs de l'étude économique du système envisagé.

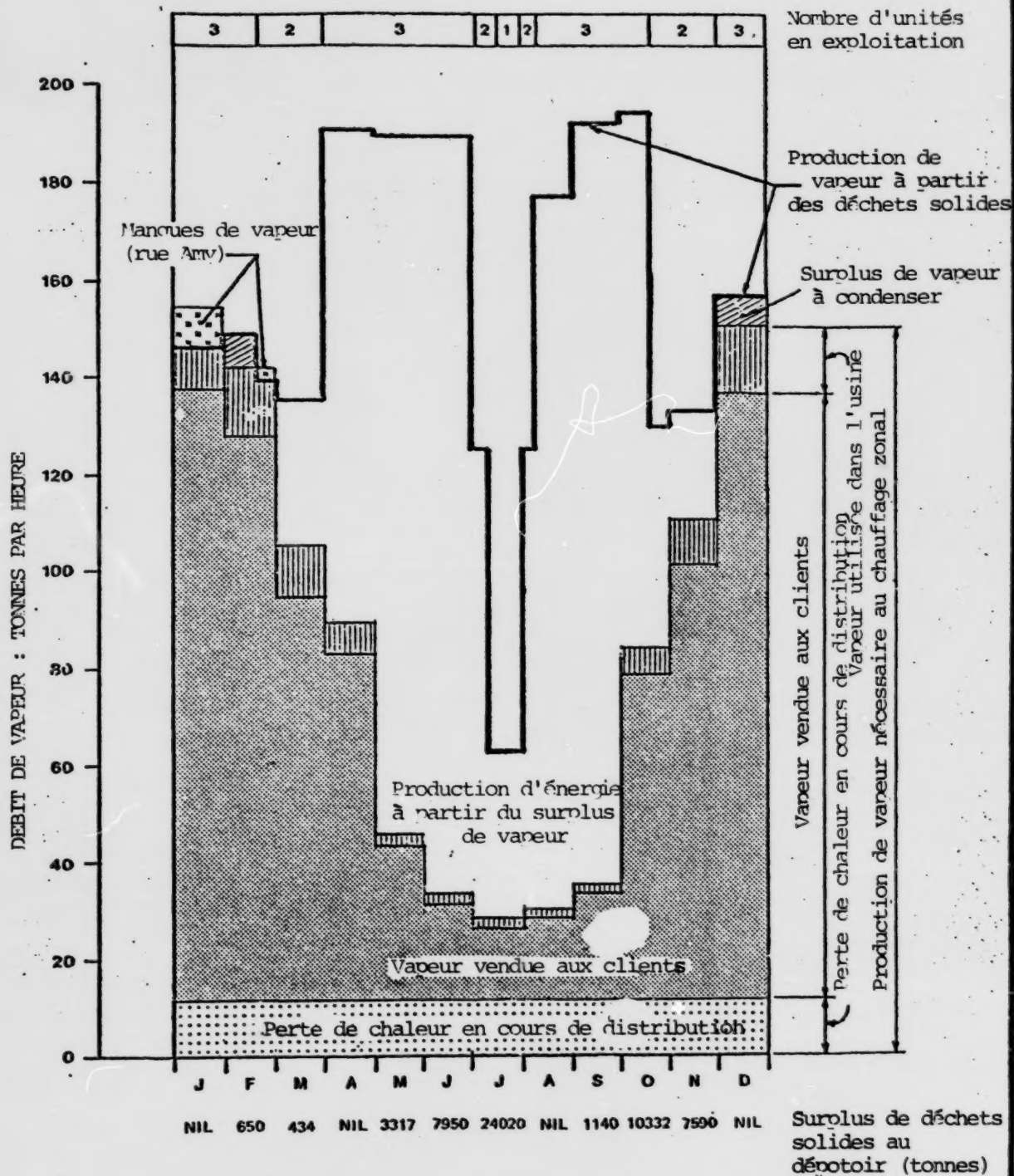
L'établissement du prix de la vapeur a été effectué par l'analyse des coûts évités, dans laquelle on détermine le prix de revient, pour le consommateur, de la conversion à la source de combustible la moins coûteuse. Les prix (en dollars de 1983) devraient diminuer au cours des premières années du projet, puis augmenter par la suite. Cette diminution est en partie due à une "ristourne" pour attirer les clients au début de la mise en activité, qui sera supprimée par la suite.

Combustibles

Le combustible principal de l'installation EPD sera les déchets solides municipaux (DSM). La quantité de déchets dont on pourra disposer a été déterminée et extrapolée au cours de la durée de vie de l'installation. La production de déchets suit un schéma mensuel établi. Les résultats de l'extrapolation ont servi à la détermination des dimensions de l'installation.

La combustion des DSM diminue d'autant la quantité de matières à mettre aux dépotoirs et l'installation d'une usine au centre de Winnipeg diminuera les coûts de transport des déchets. Les économies envisagées sont de l'ordre de 3,2 millions de dollars (1983) en 1990 avec accroissement subséquent. Étant donné qu'il s'agit de "coûts évités" grâce au projet, ils sont considérés comme des revenus, c'est-à-dire dans le cas présent comme des droits de déchargement dans l'analyse économique.

Étant donné que la demande d'énergie au cours des premiers hivers de la vie du projet ne pourra être satisfaite par les DSM à eux seuls, on a étudié le prix et la disponibilité de combustibles auxiliaires. Des résultats ont été appliqués à l'analyse économique afin de déterminer le coût des services de pointe en hiver.



VILLE DE WINNIPEG ETUDE DU CHAUFFAGE ZONAL
BILAN ENERGETIQUE MENSUEL - 1990

FIGURE 1.1

La province du Manitoba envisage la construction d'une installation d'élimination des déchets dangereux et il n'est prévu aucun rôle pour la présente usine à ce sujet. Les revenus que l'on pourrait tirer de l'élimination des déchets spéciaux moins dangereux sont peu élevés et l'équipement nécessaire à leur manipulation augmenterait les frais d'immobilisation relatifs à l'installation. À l'heure actuelle, il n'est rien prévu dans le cas présent au sujet des déchets spéciaux.

Énergie produite par l'installation d'incinération des déchets

De nombreuses combinaisons de techniques, de besoins en énergie, de dimensions de l'installation et de sites ont été envisagées avant que l'on arrive à la configuration finale adoptée. L'usine choisie comprend trois unités de combustion de masse pouvant brûler chacune 500 tonnes de DSM par jour. Les chaudières produiront de la vapeur à 3 000 kPa (420 lb/po²) et 320°C (608°F). Chaque unité fonctionnera 7 500 heures par an et sera arrêtée 1 260 heures par an pour nettoyage et entretien. L'usine brûlera 89 % des déchets solides incinérables recueillis à Winnipeg en 1990 et 69 % en 2 019 s'il n'y a pas agrandissement d'ici là. La vapeur produite sera acheminée au réseau de chauffage zonal. Aux beaux jours, la vapeur en excès servira à la production d'électricité grâce à l'utilisation des turbogénératrices de l'installation de la rue Amy. Cette électricité sera vendue à Hydro Manitoba/Hydro Winnipeg à un coût évalué à 1,2 cents par kilowatt-heure.

La technique adoptée pour le projet est une méthode bien au point qui a déjà été appliquée dans de nombreuses installations en Amérique du Nord et en Europe. Les incinérateurs brûlent des DSM bruts sur des grilles, en évitant de la sorte les étapes de préparation du combustible qui sont la cause de la plupart des problèmes des usines à combustion en suspension.

La vapeur supplémentaire qu'il sera nécessaire d'obtenir aux périodes de pointe, au cours des mois d'hiver, sera fournie par une chaudière de l'installation de la rue Amy qui sera convertie pour fonctionner au gaz. La figure 1.1 présente un graphique des variations mensuelles du fonctionnement de l'usine et du système pour l'année 1990. Dans le cadre de

l'approvisionnement des futurs clients, il pourrait être possible d'utiliser certains des générateurs de vapeur servant actuellement à l'approvisionnement de clients plus importants pour les périodes de pointe.

Les gaz de carneau émis par les incinérateurs passeront dans un système d'épuration et seront rejetés par une cheminée de 100 m de haut. Les émissions auront des caractéristiques inférieures aux limites établies dans le cadre de tous les règlements actuellement en vigueur ainsi que des exigences plus sévères qui caractériseront tous les règlements actuellement à l'étude. On a prévu sur le site la place nécessaire à la construction d'une quatrième unité si le besoin s'en faisait ressentir par la suite.

Réseau de distribution

La vapeur a été choisie comme moyen de transport de la chaleur pour deux raisons :

- La plupart des nouvelles installations prévues ont besoin de vapeur pour le fonctionnement de leurs systèmes.
- Le système de chauffage zonal actuel qui existe en ville utilise de la vapeur.

Des prolongements du réseau actuel de distribution de vapeur ont été conçus en fonction des besoins des nouveaux clients identifiés. Ils représentent 6,8 km de long, et leur construction est évaluée à 11,5 millions de dollars (1983). Étant donné que les clients actuels seront servis à partir du nouveau système, le réseau existant devra subir d'importantes rénovations, dont le coût se monterait à 9,0 millions de dollars (1983). Bien que l'on ne récupère actuellement pas de condensat auprès des clients actuels, il est prévu de le faire dans le cas des nouveaux clients importants. Les nouvelles conduites de vapeur seront enfermées dans des gaines en béton prémoulées, enterrées sous les chaussées de la ville. Les conduites de retour du condensat seront installées en dehors des gaines dans la même tranchée.

Considérations environnementales

On a étudié les problèmes éventuels que poserait à l'environnement l'exploitation d'une usine EPD (1 500 tonnes par jour) dans le centre de Winnipeg, et l'on a conclu qu'une telle installation n'aurait pas de conséquence négative marquante pour l'environnement. Le principal problème serait probablement la libération de la fumée dans l'air par la cheminée. Étant donné que l'usine sera équipée d'un dispositif efficace d'épuration des gaz de carneau, tous les règlements actuels et toutes les directives des règlements futurs actuellement envisagés pourront être respectés.

La condensation de la vapeur servant à produire de l'électricité à l'usine de la rue Amy nécessitera un apport d'eau de refroidissement en provenance de la rivière Rouge. La décharge thermique dont sera l'objet la rivière a été étudiée et l'augmentation moyenne de température de l'eau de la rivière (au moment des basses eaux) dépasserait légèrement la limite de 1°C définie dans les objectifs de qualité des eaux de surface proposés en 1981. La Division manitobaine de la gestion de l'environnement étudie actuellement ces objectifs et l'on ne peut pour l'instant savoir s'ils seraient respectés. Ce facteur devra être étudié plus en détail lors de l'évaluation des conséquences pour l'environnement et il pourrait nécessiter une limitation de la production aux périodes sensibles où la vie aquatique coïncide avec les basses eaux, ce qui ne devrait pas se produire très fréquemment et ne devrait donc pas influencer sérieusement sur l'aspect économique du projet.

Les cendres produites seront éliminées sous forme de matériaux de remblayage. Il s'agit de cendres relativement stériles qui causeront moins de problèmes à l'environnement que l'élimination des déchets solides telle qu'elle se pratique actuellement.

Les DSM seront livrés à l'usine dans des véhicules fermés et déchargés dans un lieu clos. Il n'en résultera qu'un supplément de circulation d'environ 2 %, ce qui n'aura pas de conséquence marquée dans les rues voisines.

Considérations socio-économiques

Parmi les avantages que présente ce projet pour la Ville de Winnipeg, on peut citer une intéressante récupération d'énergie à partir de déchets, une réduction de la surface des dépotoirs, une économie de transport des déchets et des frais correspondants, une extension de la durée d'utilisation des dépotoirs qui existent et un meilleur délai de planification des futurs dépotoirs. De plus, le projet pourrait apporter un soutien important au dynamisme du centre-ville grâce à des approvisionnements en énergie à coût moins élevé, et entraîner la création d'emplois pendant la construction et l'exploitation de l'usine. Grâce à une étude intelligente de l'architecture de l'édifice, on pourrait améliorer l'environnement urbain, y compris la remise en état des bords de la rivière dans le centre-ville. En plus de l'installation elle-même, avec la conversion au gaz de celle de la rue Amy, il y aurait élimination des tas de charbon sur le bord de la rivière, ainsi que des émissions excessives de particules.

Choix du site

Le choix du site s'est fait entre huit emplacements, en fonction de seize critères relatifs à l'environnement et à la communauté, après pondération de ces critères par un comité indépendant de l'étude. Une fois le classement établi, on a déterminé les coûts relatifs à chaque site et possibilité, puis on a établi un graphique du classement en fonction des coûts, ce qui a permis de choisir le meilleur site. Celui de la rue Mill est arrivé en tête, suivi de celui de la rue Grace. Le premier se trouve près du marché de la vapeur dans le centre-ville et il est situé sur un terrain qui appartient en grande partie à la municipalité. Il présente le meilleur équilibre entre l'acceptation au niveau de l'environnement et du public et les coûts impliqués.

Évaluation des coûts

Les coûts de la construction de l'installation ont été évalués de la façon suivante :

<u>Élément</u>	000 \$ (1983)
Terrain et améliorations du site	3 070 \$
Édifice	14 464
Équipement	62 084
Taxes de vente, études techniques, mise en oeuvre et frais imprévus	16 240
Nouveau système de distribution	11 346
Modifications de l'installation de la rue Amy	880
TOTAL JUSQU'EN 1990	108 084 \$

Ces coûts pourraient être répartis sur quatre à cinq ans après approbation de la mise en oeuvre du projet. En supplément à ces frais, la remise à neuf du réseau de chauffage existant a été évaluée, en admettant qu'elle serait réalisée au cours des 10 premières années de l'exploitation du système, à un montant total de 9,0 millions de dollars (1983). Les frais nécessaires au branchement de nouveaux clients après la mise en route du système sont évalués à 1,65 millions de dollars (1983), répartis sur toute la durée du projet.

Revenus et frais d'exploitation

Les revenus et les frais d'exploitation ont été établis pour la durée de vie du projet. Ils sont présentés ci-dessous pour certaines années choisies :

000 \$ - (Constants 1983)
(immobilisations non comprises)

ANNÉE

	1991	1996	2001	2006	2011	2016	2019
<u>Recettes</u>							
Ventes de vapeur	9213	8128	8366	8650	8773	8834	8896
Droit de déchargement	2970	3102	3019	3087	3280	3471	3471
Vente d'électricité	1451	1525	1599	1697	1771	1894	1919
Recettes totales	13 634	12 755	12 984	13 434	13 824	14 199	14 286
<u>Frais</u>							
Main-d'oeuvre de l'installation	3506	3506	3506	3506	3506	3506	3506
Combustible de démarrage	4	5	5	5	5	5	5
Achat d'électricité	487	385	395	411	411	411	411
Usine de la rue Amy	600	600	600	600	600	600	600
Combustible de pointe	96	98	65	-	-	-	-
Réseau de chauffage zonal	620	620	670	613	613	613	613
Autre	452	457	463	466	468	469	471
Total des frais	5 765	5 671	5 704	5 601	5 603	5 604	5 606
Encaisse nette du projet	7 869	7 084	7 280	7 833	8 221	8 595	8 680

Analyse économique

Les avantages économiques du projet ont été évalués en procédant à une analyse du flux monétaire actualisé. Cette analyse a été reprise périodiquement au cours de l'étude au fur et à mesure de la disponibilité de données plus précises. Il en a résulté que l'on considère le projet comme viable. Il s'agissait d'une analyse stratifiée des mouvements de trésorerie affectant l'installation elle-même, Hydro Winnipeg, la Ville de Winnipeg, la province du Manitoba, le gouvernement fédéral et la société dans son ensemble.

Le gouvernement du Canada a actuellement un programme de subvention appelé "Programme d'énergie renouvelable de l'industrie forestière" (ERIF). Ce programme permet d'accorder une subvention aux projets qui font appel aux ressources renouvelables; cette subvention peut couvrir jusqu'à 20 % du coût de l'installation, de l'équipement et du système de distribution. Le présent projet entre dans cette catégorie puisqu'il utiliserait les déchets municipaux comme source d'énergie en remplacement de l'énergie achetée. La date limite de la demande de subvention est le 31 mars 1986. Elle se monterait dans le cas présent à environ 21 millions de dollars à la date de la mise en service de l'usine.

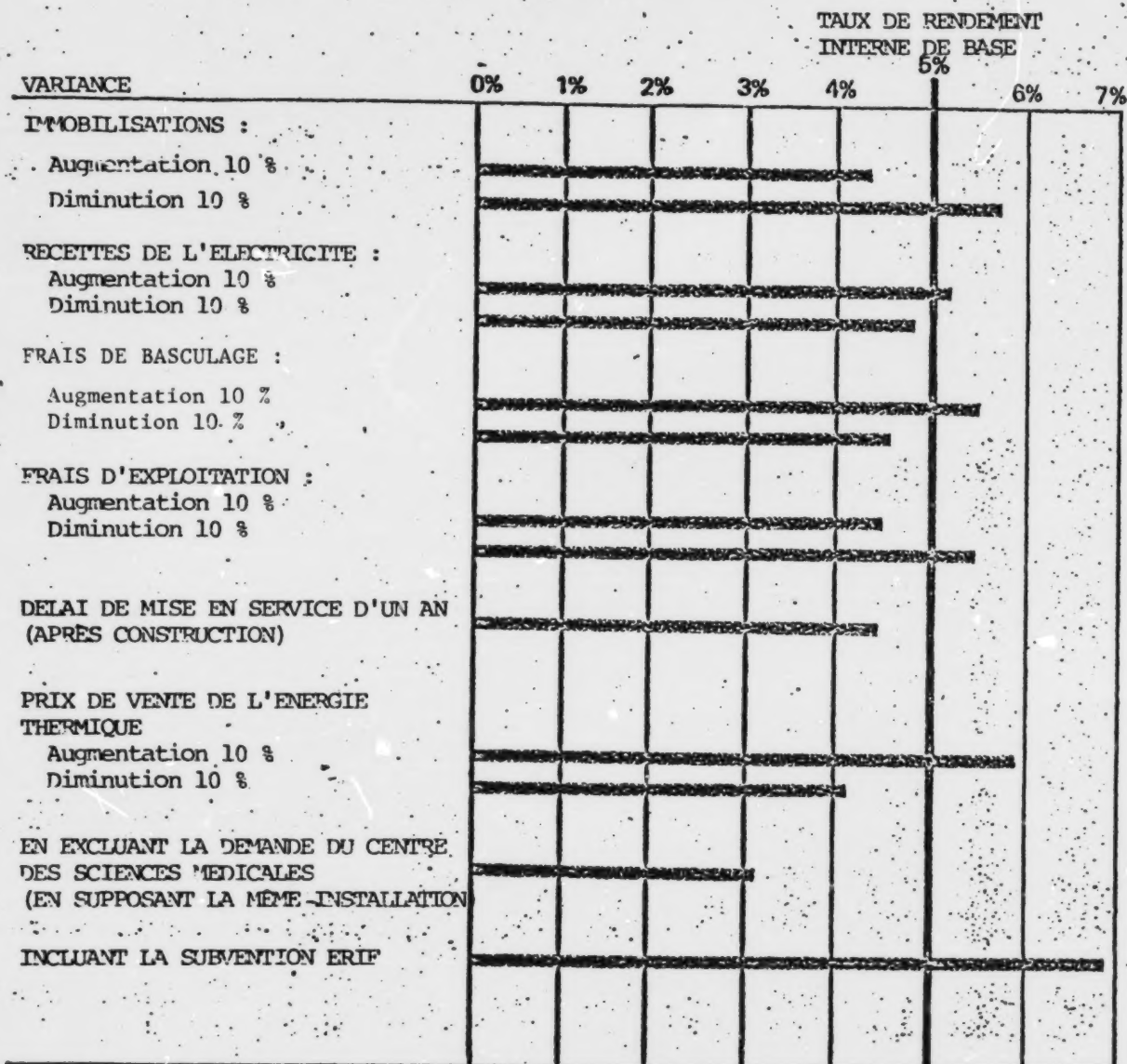
Le taux réel de rendement interne (sans tenir compte de l'inflation) dans le cas du projet retenu, aux divers niveaux d'analyse, est le suivant :

<u>Niveau</u>	<u>Taux de rendement interne</u>	
	<u>(sans subvention)</u>	<u>(avec subvention ERIF)</u>
Projet	5,04	6,86
Hydro Winnipeg		10,35
Ville de Winnipeg		10,39
Province du Manitoba		10,45
Gouvernement fédéral		10,46
Société		11,92

Comme on le voit, le projet assure un taux de rendement réel (sans inflation) de 5 % au niveau du projet lui-même. Avec la subvention, ce taux augmente, passant à 6,9 %. Le taux de rendement réel sera supérieur aux chiffres ci-dessus, par suite de l'inflation.

On a procédé à une analyse de variance des intrants afin de déterminer l'impact que ces changements auraient sur les aspects économiques du projet. Les résultats sont présentés à la figure 1.2, qui montre que si les variations des recettes retirées de la vente de vapeur et des immobilisations ont l'influence la plus marquée sur les bénéfices du projet, ce dernier n'est pas particulièrement sensible à des modifications modérées de n'importe laquelle des variables.

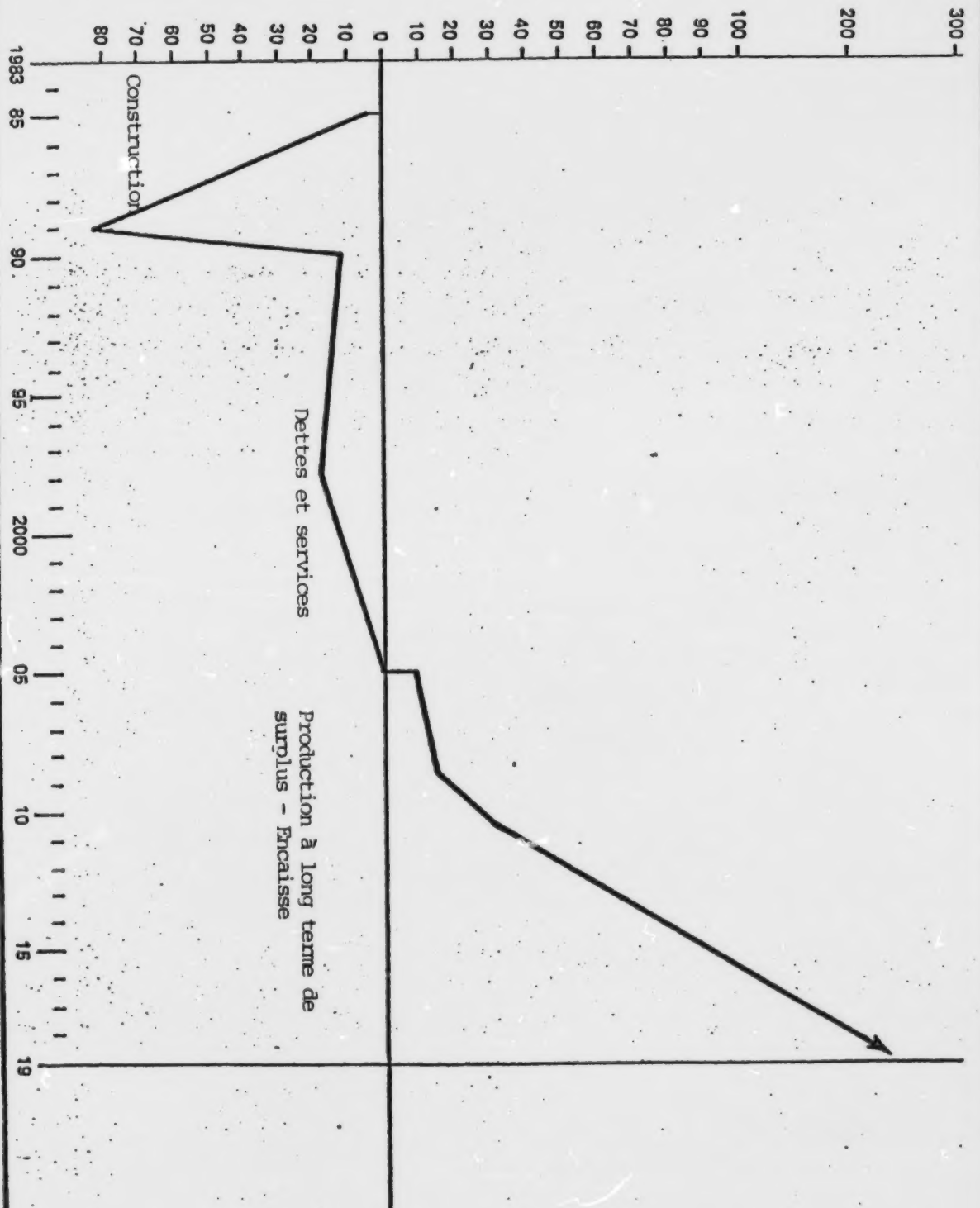
TAUX DE RENDEMENT INTERNE DU PROJET



VILLE DE WINNIPEG - ETUDE DE CHAUFFAGE ZONAL
ANALYSE NUANCEE

FIGURE 1.2

ENCAISSE ANNUELLE
 PLAN DE FINANCEMENT TENANT COMPTE DE L'INFLATION
 (inflation 8 %, intérêt 12 %)
 millions de dollars



VILLE DE WINNIPEG - ETUDE DE CHAUFFAGE ZONAL
 ENCAISSE ANNUELLE AU NIVEAU DU PROJET

FIGURE 1.3

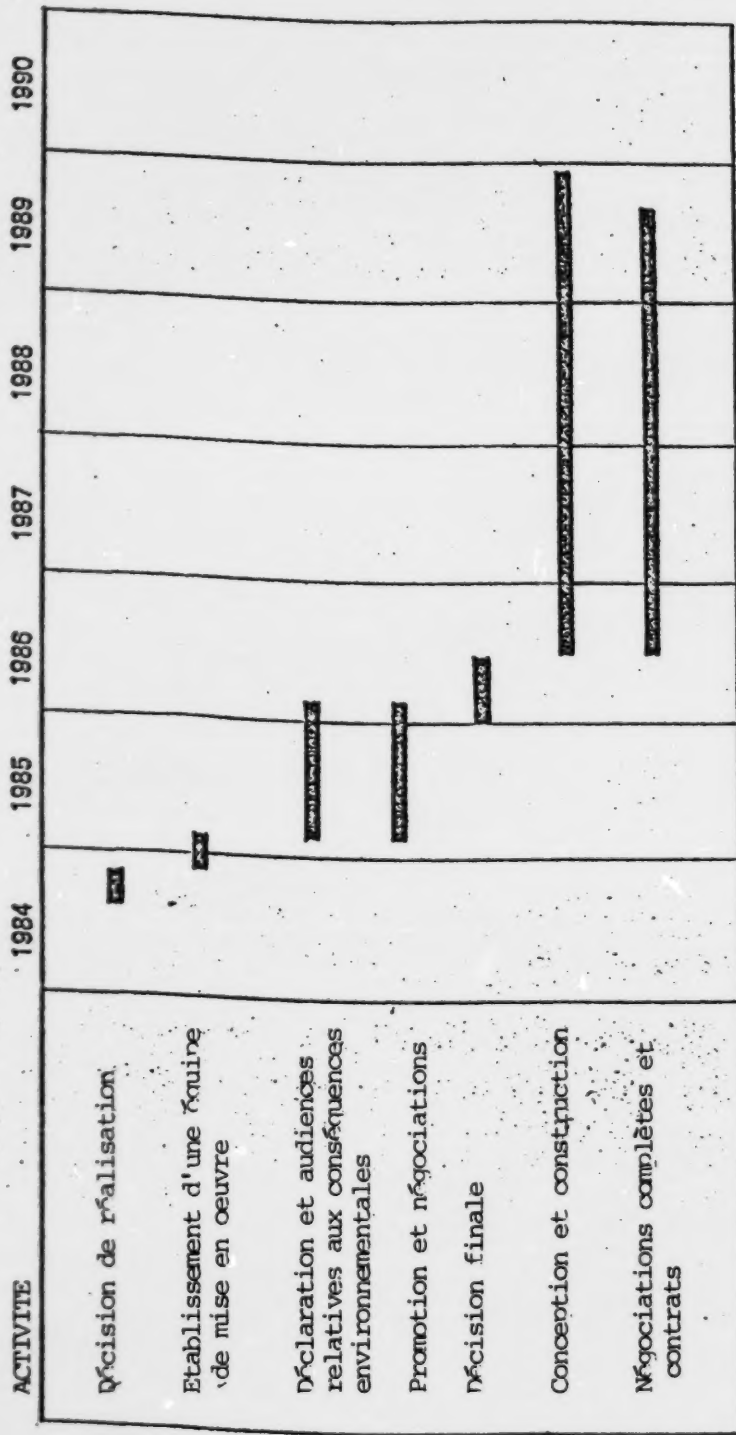
À titre d'exemple, une analyse économique a été effectuée en supposant une inflation de 8 % et un intérêt de 12 %. Il en a résulté que les frais de construction, en tenant compte de l'inflation et en incluant un intérêt pendant la période de construction, se monteraient à environ 180 millions de dollars. Le total des dettes, toujours en tenant compte de l'inflation, atteindrait un maximum de 300 millions de dollars, treize ans après la mise en service de l'installation. Celle-ci serait totalement rentabilisée après 25 ans de fonctionnement et disposerait de plus d'un milliard de dollars, compte tenu de l'inflation, à la fin de la période d'exploitation de 30 ans. L'encaisse annuelle du projet dans le cas de cet exemple est présentée à la figure 1.3.

L'étude économique a consisté aussi à voir de quelle façon financer le projet. Étant donné les faibles recettes prévues et les risques envisagés, ce projet ne semble pas être suffisamment intéressant aux yeux d'investisseurs privés, ce qui a été confirmé lors d'entrevues avec certains d'entre eux. Puisque la plus grande partie des bénéfices indirects reviendrait à la Ville de Winnipeg, il a été conclu que la meilleure solution consisterait à exploiter le système comme service municipal financé par la municipalité. Il y aurait dans ce cas un intéressant bénéfice sur l'investissement.

Mise en oeuvre

La mise en oeuvre du projet, depuis la réception du présent rapport jusqu'à la mise en service et l'exploitation de l'installation, nécessitera une planification attentive. L'expert-conseil a étudié la séquence des événements et basé son rapport sur ce que l'on considère comme un scénario optimiste. Il suppose un désir marqué de procéder rapidement à la mise en exploitation du système. Dans ce cas, les étapes sont les suivantes :

ANNEES



VILLE DE WINNIPEG - ETUDE DE CHAUFFAGE ZONAL
 CALENDRIER DE MISE EN OEUVRE
 SERVICE PUBLIC - SCENARIO RAPIDE

FIGURE 1.4

- . Décision de réaliser le projet - Elle sera prise après une étude attentive du rapport - Mois 3.
- . Équipe de mise en oeuvre - Il s'agit de mettre sur pied une équipe qui aura pour mandat d'analyser le projet, de planifier sa réalisation et de mettre en oeuvre les plans - Mois 6.
- . Présentation et audiences relatives aux conséquences environnementales - C'est une étape qui peut être nécessaire pour obtenir l'approbation de la Commission de protection de l'environnement et informer le public sur les questions qui peuvent le préoccuper - Mois 18.
- . Promotion et négociations - En parallèle avec l'étude environnementale, il s'agira de développer de façon plus complète et de promouvoir le projet auprès des clients éventuels, d'obtenir des engagements du gouvernement, de commencer des négociations préliminaires de contrat et d'établir une entente de principe pour l'achat par Hydro Manitoba/Hydro Winnipeg de l'électricité produite à l'usine de la rue Amy. Il faudra étudier les implications juridiques, définir les détails des contrats et étudier les arrangements financiers - Mois 18.
- . Décision finale relative à la réalisation - Après avoir obtenu les informations ci-dessus, on procédera à une analyse économique, au raffinement du projet selon les besoins, puis une décision sera prise de le réaliser ou de l'abandonner - Mois 22.
- . Conception et construction - Il s'agit à ce niveau d'établir les contrats permettant de procéder à la conception finale de l'installation, aux appels d'offres préalables pour l'équipement ainsi qu'à la construction. On procédera aussi à la mise en place de l'équipement et au démarrage du système - Mois 64.
- . Négociations définitives et contrats - En parallèle avec l'activité précédente, on procédera à l'ensemble des négociations avec toutes les parties concernées et à l'établissement des contrats - Mois 60.

Le programme complet de mise en oeuvre devrait durer 64 mois si toutes les activités se déroulent normalement sans délai entre les diverses étapes. Partant de la soumission du présent rapport en août 1984, l'installation sera opérationnelle en décembre 1989. Les clients pourraient donc commencer à être servis au cours de l'hiver 1989-90. Ce plan est présenté à la figure 1.4.

Pour qu'il soit réalisable, ce plan nécessite que les décisions soient prises rapidement et que la volonté d'achever le projet soit ferme. Si l'on considère un autre plan plus prudent, dans lequel les activités seraient planifiées à la suite l'une de l'autre et non en parallèle, et où il serait prévu des délais d'évaluation périodique et de prise de décision, on pourrait avoir besoin de jusqu'à deux années supplémentaires.

En résumé, il est possible de mettre en service un système de chauffage zonal utilisant les déchets municipaux, qui soit acceptable au niveau de l'environnement et économiquement viable, pour la Ville de Winnipeg. Il s'agirait d'un service municipal qui pourrait être mis en exploitation au cours de l'hiver 1989-1990.

Notes :

Pour de complètes informations sur le sujet, le lecteur est prié de prendre connaissance des résumés qui suivent la présente partie 1 - Résumé, ou des rapports subséquents indiqués ci-dessous :

- Volume II - Partie 2 - Recherche de marchés
Partie 3 - Déchets solides et autres combustibles
- Volume III - Partie 4 - Usine EDP
Partie 5 - Réseau de distribution
- Volume IV - Partie 6 - Considérations environnementales et socio-économiques
Partie 7 - Choix du site
- Volume V - Partie 8 - Analyse économique
Partie 9 - Considérations relatives à la mise en oeuvre

PART 1 - SUMMARY

1.1 INTRODUCTION

1.1.1 Background

The City of Winnipeg has operated a district heating system serving the central area of the City since 1924. Steam is generated primarily by a coal burning plant at Amy Street and distributed to 215 customers through a network of buried steam pipes. Coal is supplied to the plant in rail cars on the transfer track along the Red River and stored in a coal stockpile adjacent to the Amy Street plant. The present system incurs an operating deficit which varied between \$135,000 and \$705,000 per annum over the past five years. The Amy Street plant also contains steam turbo-generators for emergency generation of electricity.

The existing coal-fired plant is under a Clean Environment Commission order (expiring in September, 1985) to install pollution control equipment to reduce emissions to the atmosphere. Other plant upgrading is also required. The total capital cost for these modifications and including required distribution system upgrading has been previously estimated at \$20 million. This upgrade would keep the existing system operational for an additional 30 to 40 years but would not alleviate the operating deficit in itself.

In view of escalating costs of coal used as fuel, the costs of required modifications to the Amy Street system, and a desire to review the management of municipal solid waste within the City, the City of Winnipeg decided to commission a study into the economic viability of district heating for the central area of the City of Winnipeg. The Manitoba/Canada Conservation and Renewable Energy Development and Demonstration Agreement provided the necessary monetary assistance to allow a study to proceed. Funding was provided equally by the Federal Government, the Province of Manitoba and the City of Winnipeg.

The study was commissioned in two phases. Phase I of the study was of limited scope and was intended to provide a preliminary indication of viability. This Phase of the study, completed in October of 1982, indicated that a viable system was possible and that significant benefits could accrue to the City of Winnipeg.

1.1.2 Phase II

In March of 1983, Phase II, a detailed study was commissioned. W. L. Wardrop & Associates Ltd. and SNC Inc. were retained to carry out the study in association with MacLaren Engineers Inc. and Woods Gordon.

The major elements of the Phase II study are:

- . Assessment of markets for district heating.
- . Evaluation of solid waste and other fuels.
- . Preparation of conceptual EFW plant design.
- . Determination of distribution system configuration.
- . Assessment of environmental and socio-economic considerations.
- . Selection of a site for the plant.
- . Determination of project economics.
- . Preparation of a plan for project implementation.

This Phase II study proceeded through Milestone No. 1 in June, 1983, Milestone No. 2 in October, 1983 and culminated in this final report.

1.1.3 Report Arrangement

The report is presented in five volumes. This volume (Volume I) is a summary of the detailed reports contained in Volumes II to V. For details on a particular subject area reference should be made to subsequent volumes as follows:

EXECUTIVE SUMMARY

Volume I - PART 1 - SUMMARY

Volume II - PART 2 - MARKET PROSPECTS
- PART 3 - SOLID WASTE AND OTHER FUELS

Volume III - PART 4 - EFW PLANT
- PART 5 - DISTRIBUTION NETWORK

Volume IV - PART 6 - ENVIRONMENTAL AND SOCIO-ECONOMIC
CONSIDERATIONS
- PART 7 - SITE SELECTION

Volume V - Part 8 - ECONOMIC ANALYSIS
- Part 9 - IMPLEMENTATION CONSIDERATIONS

TABLE 1.1
DISTRICT HEAT SALES
TOTAL REVENUE AND VOLUME FORECASTS
(\$1983)

<u>Year</u>	<u>Volume (GJ)</u>	<u>Price (\$/GJ)</u>	<u>Revenue (\$000)</u>
1990	1,393,600	7.10	9,904
1991	1,405,300	7.02	9,869
1992	1,416,900	6.78	9,608
1993	1,428,500	6.50	9,290
1994	1,440,100	6.34	9,140
1995	1,451,700	6.12	8,893
1996	1,463,300	5.94	8,698
1997	1,474,900	5.82	8,590
1998	1,486,500	5.71	8,486
1999	1,498,100	5.71	8,545
2000	1,504,400	5.89	8,860
2001	1,508,600	5.95	8,978
2002	1,512,900	5.95	9,004
2003	1,517,100	5.95	9,030
2004	1,521,300	5.95	9,056
2005	1,524,500	6.03	9,187
2006	1,527,600	6.03	9,207
2007	1,530,800	6.03	9,227
2008	1,534,000	6.03	9,248
2009	1,537,100	6.03	9,265
2010	1,540,300	6.03	9,286
2011	1,543,500	6.03	9,306
2012	1,546,600	6.03	9,327
2013	1,549,800	6.03	9,347
2014	1,553,000	6.03	9,368
2015	1,556,100	6.03	9,389
2016	1,558,200	6.03	9,402
2017	1,560,300	6.03	9,416
2018	1,562,500	6.04	9,430
2019	1,564,600	6.04	9,444

1.2 MARKET PROSPECTS

In order to assess viability for the proposed Energy from Waste (EFW) District Heating System, it was necessary to develop confidence that the products produced can be sold and to assess the price that prospective customers will pay for the products. The two main products produced by the facility will be steam for district heating and electricity generated during periods of low demand by the heat customers.

It has been concluded that customers for heat can be attracted to join the system in sufficient numbers that a viable system will result. The projected revenue from the sale of district heat is as shown in Table 1.1 (price levels are discussed in a subsequent section of this report). This revenue is used in subsequent economic analyses which assess system viability.

Electricity generated will be sold to the Manitoba Hydro/Winnipeg Hydro system. It has been determined that a price of 1.2 cents per kilowatt hour can be charged for this power.

1.2.1 Methodology

The methodology used was:

- Review relevant literature
- Contact other district heating systems
- Interview potential customers
- Estimate likely sales volumes and unit selling prices for products from a district heating plant, after considering price forecasts for alternative energy sources.

1.2.2 Customer Decision Factors

Interview results and the experience of other district heating systems indicates that a real or perceived economic advantage must be offered to potential customers to induce them to join a district heating system. It should be stressed however that an economic advantage, while typically necessary to a decision to convert, is in itself not sufficient. Qualitative factors will affect the final decision. Some of the more likely qualitative considerations are:

Positive Factors:

- A conversion to district heat can eliminate the need for major capital expenditures in buildings with aging heating plants. This short term cash flow and financing benefit can be as, or more, important than long term costs per unit of energy.
- District heat can reduce the skill levels (and in a few cases the numbers) of building maintenance personnel required, resulting in building operating cost savings.
- District heat insulates the building owner from international influences on energy prices. This "local control" has appeal to some consumers.
- Other factors being equal, there is some preference in the marketplace for "products" which support local enterprise and which contribute to energy conservation.
- The use of district heat permits greater utilization of available building floorspace through the elimination of boiler facilities. This can be significant under certain circumstances.

Negative Factors:

- Potential savings may not be large enough to warrant management's attention, or declining alternative energy costs may favour a postponement of any conversion decision.
- It may be a requirement that savings are passed on to tenants (i.e. net/net leases) leaving no incentive for the building owner to convert. Note, however, that the significance of this point depends upon the vacant building space available in the marketplace at the time. In a "buyers' market", lower occupancy costs would in fact be viewed as a positive factor, a selling tool, by the owner.
- The customer may not believe the economic benefits are real or can be sustained. The customer may be concerned over their future vulnerability to price increases once a conversion has been made.
- There may be perceived risks associated with the use of "new technology". These could include:
 - . concern over potential interruptions;
 - . concern over any difficulty or inconvenience in the initial "hook up";
 - . concern that their own special needs (quality, quantities of heat) cannot be met by the system.
- There may be resistance to change an existing heating system which is relatively new, or in the view of the owner, is working efficiently.
- Alternate energy sources such as natural gas and electricity have a very positive image. They may compete vigorously to retain their customers.

Clearly there are many reasons why pure economics may not be sufficient to induce customers to join the district heating system. Accordingly, proper marketing of the concept will be a critical task.

If energy from a district heating plant is perceived to be reliable, if it is priced competitively with readily available alternate energy sources, and if it is aggressively and professionally marketed, there is a high probability that customers can be attracted to join the district heating system.

The rate at which customers join the system will be influenced by a number of factors such as:

- Ownership or sponsorship of the district heating system.
- The quality of selling effort put forward by management of the system.
- Individual customer factors such as the relative significance of their energy costs to their total operation and the condition of their current heating systems.
- The rate of price increases being experienced by alternate energy sources.

Given the significant capital investment required for an Energy From Waste (EFW) district heating system, it will be essential to obtain commitments from customers for heat volume prior to construction. This step is necessary to reduce the risk associated with financing a project of this magnitude.

Other plants have experienced marketing efforts taking up to 2.5 years to contract a base load.

1.2.3 Market Location and Size

The initial marketing focus should be on larger institutional or commercial customers in the downtown area.

Structuring the system to serve customers outside downtown would significantly increase the risks associated with this project due to the increased investment in distribution costs and the increasing dispersion of significant customers who are likely to continue to exist over the life of the project.

The total market for heat in the downtown area in 1983 is estimated at 2,195,000 GJ/year. The district heating system will compete for a share of this total market.

It was not possible to predict with confidence any circumstances which are likely to cause dramatic shifts in the size of this total market and accordingly it has been assumed that the total market will remain at or near its present level over the life of the project.

There will likely be some net new construction of larger structures during the life of the project. These structures represent the most likely additional customers for the proposed district heating system following system start-up.

1.2.4 Probable Demand for EFW Plant Heat Energy

It is estimated that the probable demand in the downtown area for heat energy from the EFW plant will range from a minimum of 527,000 GJ to a maximum demand of 960,000 GJ in 1990.

TABLE 1.2
REVENUE AND VOLUME FORECAST
(\$ 1983)

Year	Downtown			Health Sciences Centre			Total		
	Volume (10 ³ GJ)	Price (\$/GJ)	Revenue (\$000)	Volume (10 ³ GJ)	Price (\$/GJ)	Revenue (\$000)	Volume (10 ³ GJ)	Price (\$/GJ)	Revenue (\$000)
1990	787	7.75	6104	607	6.27	3800	1394	7.10	9904
1991	799	7.52	6005	607	6.37	3864	1405	7.02	9869
1992	810	7.25	5877	607	6.15	3731	1417	6.78	9608
1993	822	6.97	5725	607	5.88	3565	1429	6.50	9290
1994	833	6.81	5673	607	5.72	3467	1440	6.34	9140
1995	845	6.58	5558	607	5.50	3335	1452	6.12	8893
1996	857	6.38	5467	607	5.33	3231	1463	5.94	8698
1997	868	6.25	5428	607	5.21	3162	1475	5.82	8590
1998	880	6.12	5387	607	5.11	3099	1487	5.71	8486
1999	891	6.11	5446	607	5.11	3099	1498	5.71	8545
2000	898	6.34	5698	607	5.21	3162	1504	5.89	8860
2001	902	6.41	5781	607	5.27	3197	1509	5.95	8978
2002	906	6.41	5807	607	5.27	3197	1513	5.95	9004
2003	910	6.41	5833	607	5.27	3197	1517	5.95	9030
2004	915	6.41	5859	607	5.27	3197	1521	5.95	9056
2005	918	6.53	5990	607	5.27	3197	1525	6.03	9187
2006	921	6.52	6010	607	5.27	3197	1528	6.03	9207
2007	924	6.52	6030	607	5.27	3197	1531	6.03	9227
2008	927	6.52	6051	607	5.27	3197	1534	6.03	9248
2009	931	6.52	6068	607	5.27	3197	1537	6.03	9265
2010	934	6.52	6089	607	5.27	3197	1540	6.03	9286
2011	937	6.52	6109	607	5.27	3197	1544	6.03	9306
2012	940	6.52	6130	607	5.27	3197	1547	6.03	9327
2013	943	6.52	6150	607	5.27	3197	1550	6.03	9347
2014	946	6.52	6171	607	5.27	3197	1553	6.03	9368
2015	949	6.52	6192	607	5.27	3197	1556	6.03	9389
2016	952	6.52	6205	607	5.27	3197	1558	6.03	9402
2017	954	6.52	6219	607	5.27	3197	1560	6.03	9416
2018	956	6.52	6233	607	5.27	3197	1562	6.04	9430
2019	958	6.52	6247	607	5.27	3197	1565	6.04	9444

Note: Revenue projections illustrated are gross revenues and include Provincial Sales Tax.
Rounded figures have been used in this table.

Governments currently directly or indirectly control 534,000 GJ or 24.3% of the total downtown market. An additional 227,000 GJ, or 10.3%, is comprised of non-government organizations who are currently Amy Street district heating system customers. It will be essential for a very large proportion of both of these customer groups to commit to the proposed system in order to achieve an initial demand of reasonable size. Selling efforts should then focus on remaining large downtown structures.

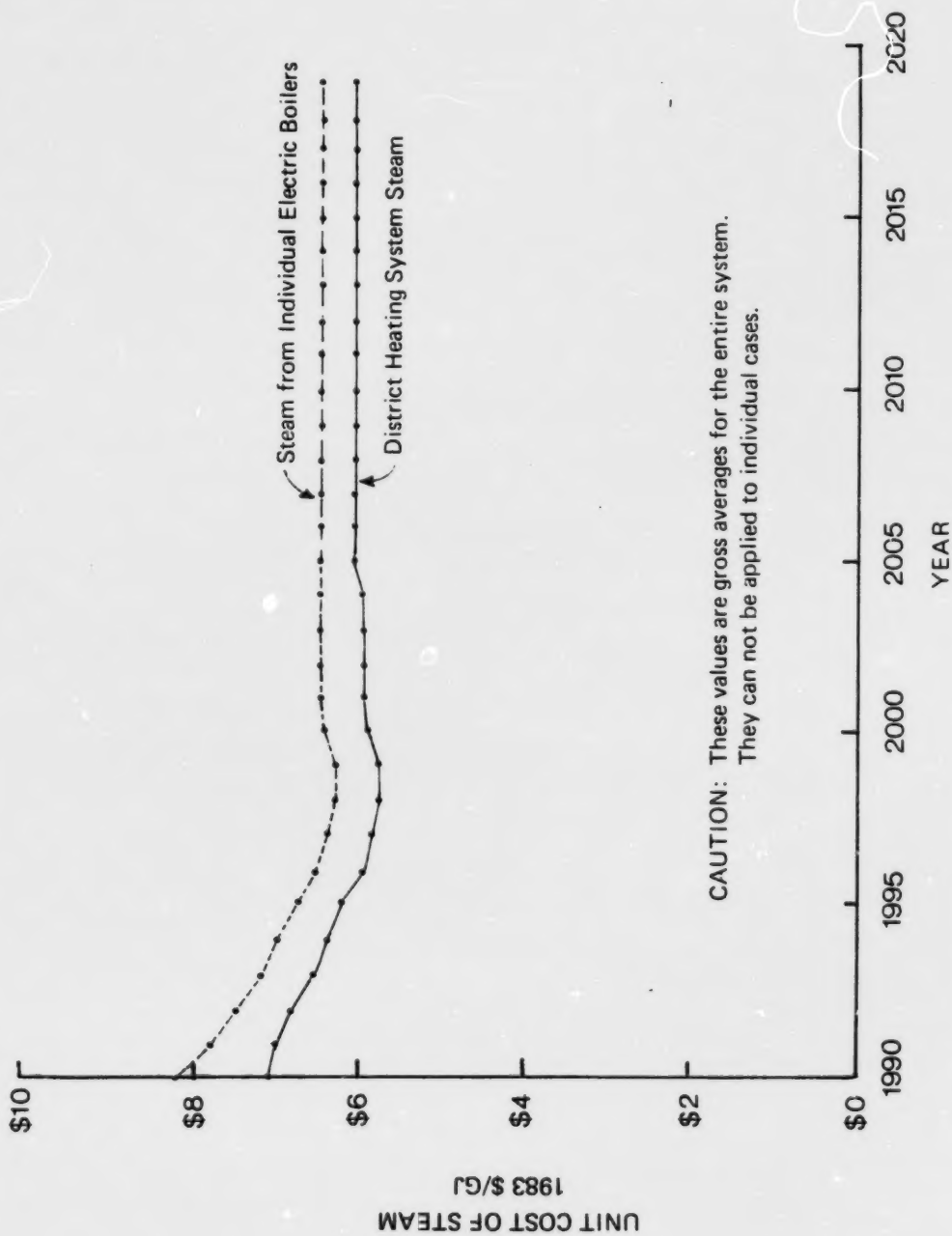
At the present time, 64 structures (6.4% of downtown structures) account for 1,048,000 GJ of heat demand per year (47% of the total downtown).

Of these 64 structures, 42 are those directly or indirectly controlled by government, and 30 are already on the Amy Street system.

Assuming strong commitment by all levels of government and current non-government Amy Street customers to the new system, the forecast of the most probable revenues and volumes which can be expected from the sale of heat by the proposed system is presented in Table 1.2.

This table indicates that downtown demand can be expected to grow slowly from approximately 787,000 GJ in 1990 to approximately 958,000 GJ by 2019. This represents an eventual market share of 45% of the total downtown heat load.

The number of potential customers, of significance, outside the downtown area is limited. However, one such customer, the Health Sciences Centre, could add an additional 607,000 GJ to the system initially. There are reasonable prospects of attracting the Health Sciences Centre to join the system. The district heating system could provide material cost savings to the Health Sciences Centre plus insulation from uncertainty in fossil fuel availability and prices. Clearly the Health Sciences Centre can have major ramifications on both project viability and plant design.



CAUTION: These values are gross averages for the entire system.
They can not be applied to individual cases.

CITY OF WINNIPEG - DISTRICT HEATING STUDY
AVERAGE UNIT COST OF STEAM VS. TIME
(1983 \$)

FIGURE 1.5

The potential for growth beyond the levels indicated in Table 1.2 exists. However, growth is expected to be slow and initial plant sizing should not anticipate substantial rapid growth above the levels forecast. There is also a potential to achieve less than the levels reflected in Table 1.2, although this is assigned a lesser probability than the prospects of doing better.

1.2.5 Price Levels

The proposed Winnipeg district heating system is unique in comparison to other systems, in that, based on currently available forecasts, the most economical alternate source of energy at plant startup in 1990 is predicted to be electricity rather than natural gas. The forecast for electrical energy was developed by the project team based on data provided by Manitoba Hydro and following discussions with Manitoba and Winnipeg Hydro personnel. The forecast has been reviewed and approved by Manitoba government personnel. The forecast for natural gas energy prices was obtained from Energy Mines and Resources in Ottawa.

This situation depresses the economic attractiveness of the project, since energy from the district heating plant will have to be priced competitively with cheaper electricity rather than more costly natural gas.

Table 1.2 indicates that selling prices are expected to decline until 1998 and then rise slightly. This trend is created by forecast real declines in the price of competing electricity. It is also influenced by the provision of "discounts" to customers in the early years of the project to create an economic incentive for them to join. The projected trends in average unit cost of steam from the district heating system and from individual electric boilers is shown on Figure 1.5.

If economic incentives were not required for government loads, the revenues indicated in Table 1.2 could be increased by approximately \$110,000 per annum in the early years of the project.

1.2.6 Price Structure

In order to maximize revenue to the project, there is a need for a price structure which can be varied.

A structure adjusted for alternate energy price changes, and reflecting the cost of each customer's most economical alternative has been selected.

A real or perceived economic benefit will have to be provided to customers to attract them to the proposed system. The analysis assumes the use of discounts, below each customer's most economical alternative, to provide this benefit. Discounts will vary from 0% to approximately 15% depending on the individual situation of the customers.

Research into rate structures indicates that this conceptual pricing mechanism could be largely achieved through a combination of customer classes (volume, interruptability, consistency of demand, etc.) and separate contracts with large customers for other than the sale of heat (e.g. repurchase of existing boiler systems).

1.2.7 Contracts and Negotiations

Contracts will be required with all customers, setting out the terms of supply. For many smaller customers these contracts will be standard and relatively straightforward. However, for larger customers, they could be unique and potentially complex.

Contracts used by other district heating systems cover periods of up to 30 years, although most have a mutual penalty-free withdrawal after five years.

The onus will be on the EFW project to develop and present proposals to customers. These proposals will have to lead a customer through an analysis of relevant issues and clearly demonstrate the benefits of district heat.

1.2.8 Other Factors

From a marketing viewpoint, steam should be used as the distribution medium rather than hot water.

All of the Amy Street system is set up for steam, as is the Health Sciences Centre and the largest downtown customers. The use of hot water may either preclude servicing some of these customers, or introduce additional conversion barriers which will have to be overcome during negotiations.

For electricity produced, there are indications that Manitoba Hydro/Winnipeg Hydro will purchase all product at a price averaging \$0.012 per kilowatt-hour, subject to electric rate inflation and year to year variations.

Steam for air conditioning is not a viable product and should not be pursued at this time. Market interviews with potential customers indicated that absorption refrigeration was not attractive to building owners/operators. In addition, greater revenue was available to the project through the use of surplus steam to generate electricity.

1.2.9 Recommendations

Efforts should be made to obtain public commitment of all government demand. This will provide a significant base load and add credibility to the project.

The Health Sciences Centre clearly represents a very significant portion of the system load and can benefit from being connected to the proposed system. Negotiations with the Health Sciences Centre should continue towards a contract for supplying their system with steam on start-up of the District Heating System.

A marketing and sales strategy should be developed, and initial contracts negotiated with all large downtown users.

Every effort should be made to retain the current Amy Street load. This may require a re-examination of the current pricing structure for Amy Street steam heat to ensure its competitiveness from now to the projected 1990 startup of the EFW plant.

Careful analysis should be made of the advantages and disadvantages of establishing a final price structure which includes a "demand" component similar to existing hydro utility price structures. This analysis will likely require detailed heat loading simulations.

The economic attractiveness of the proposed EFW district heating system is very sensitive to future changes in competing alternate energy prices. Accordingly, alternate energy trends should be closely monitored in the intervening years prior to a final go/no go decision to proceed with this project. Should major changes in alternate energy prices relative to the projections used in this report occur, it will be necessary to update the economic analysis.

1.3 SOLID WASTE AND OTHER FUELS

Municipal solid waste (MSW) will be the primary fuel for an EFW plant used in a district heat system. The study reviewed several municipal solid waste factors including the quantities of the various waste types, trends in their generation levels and trends in composition. The economic impact and the implications for future solid waste handling systems were investigated on the basis of the continued use of a landfill based system compared with the use of an EFW plant with supplementary landfill. Auxiliary fuels required for winter peaking have been reviewed for cost and availability. The role an EFW plant could play in disposal of special and hazardous wastes was also examined.

1.3.1 Municipal Solid Waste

1.3.1.1 Quantities

The types of refuse generally suitable for solid waste fuel fall into two distinct categories: residential/commercial and industrial wastes. The refuse generation levels and growth trends of each of these categories were considered in the projection of waste quantities through the study period.

The City currently generates about 435 000 tonnes/year of residential/commercial and industrial solid waste, which is projected to increase to 735 000 tonnes/year in 2019, due to population increases and increases in the per capita generation rate of MSW.

Solid waste generation exhibits a variation with time of year and year by year. Typically, refuse generation during the winter months drops to 25-30% below the annual average, and increases to 25-30% above the annual average during the spring and fall clean-up periods. On an annual basis, the residential generation rate has shown a steady increase.

Clean fill and demolition/construction wastes also represent a significant portion (more than 30%) of the total solid waste quantity generated within the City of Winnipeg. Because these types of waste are noncombustible, their continued disposal at a landfill will be necessary for both a landfill-based and an EFW-based disposal system.

1.3.1.2 Heating Value

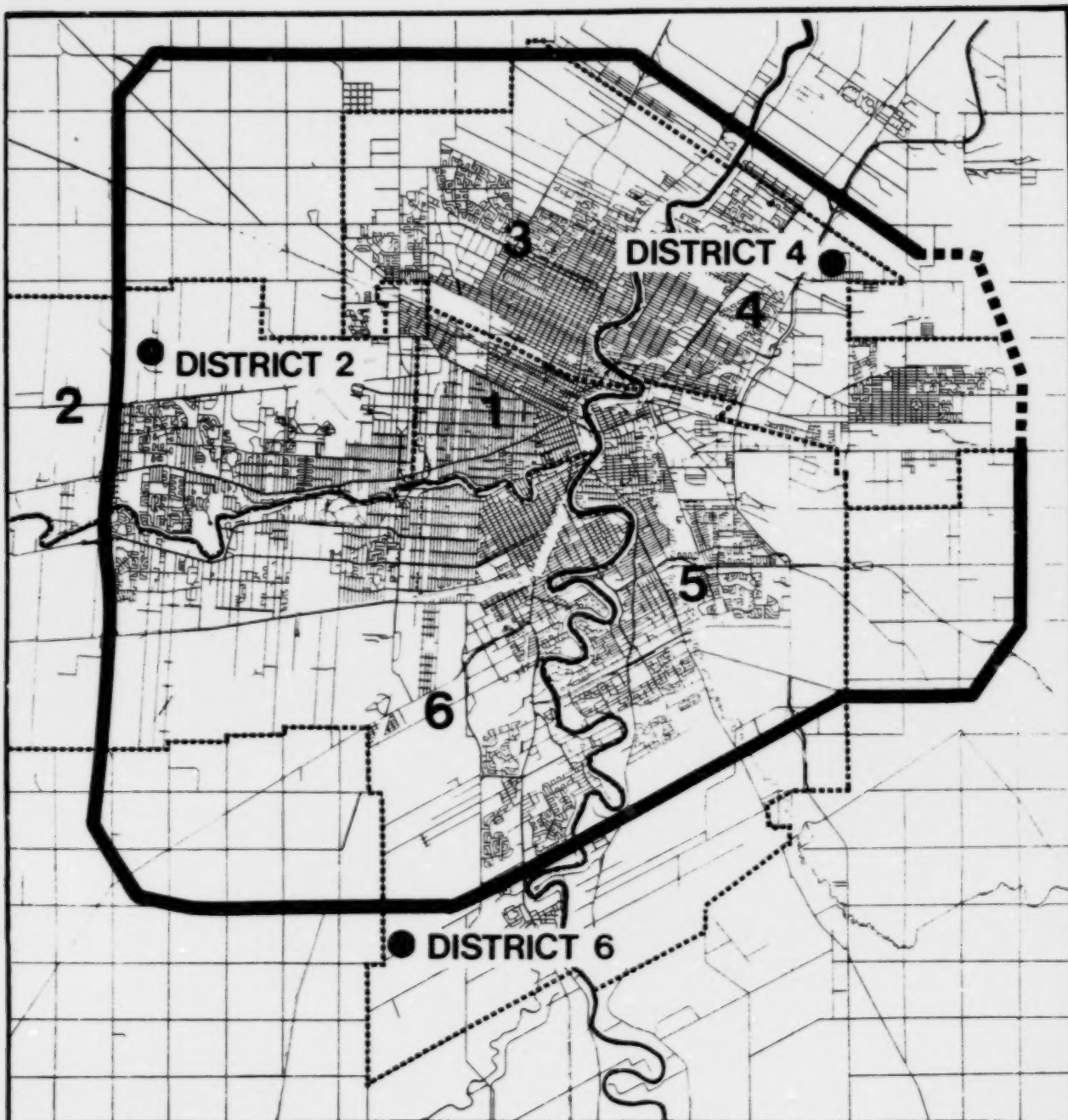
The heating value, and hence the suitability of municipal solid waste as a fuel, is dependent upon the composition of the refuse. A nation wide survey conducted in 1976 and 1977 identified the composition of Winnipeg's residential/commercial refuse but did not include industrial refuse.

A survey of industrial waste was carried out as part of this study at the three existing landfill sites. Refuse sampling was conducted during 3-day periods in the months of June, August, October and November 1983.

The industrial waste survey was based on limited sampling but nevertheless produced valuable information on the composition of the industrial waste. Sufficient data were collected to indicate that the industrial component of Winnipeg refuse is not significantly different from other cities and that the heating value is probably marginally higher than is experienced in most other North American cities where data are available.

Continued development of consumer products and new packaging technology are causing significant changes in the composition of municipal solid waste. Increased heating value of the refuse is resulting from these changes in composition and these trends are expected to continue throughout the study period.

For the purpose of this study, heating value of refuse has been determined to be 11,340 kJ/kg in 1990, and 12,870 kJ/kg in 2019.



- — ACTIVE LANDFILL SITES
- 6 — DISTRICT NUMBER

CITY OF WINNIPEG — DISTRICT HEATING STUDY
ACTIVE LANDFILL SITES

FIGURE 1.6

1.3.1.3 System Costs

An EFW plant will reduce waste disposal system haulage costs due to a more central disposal site, extend the life of existing landfill sites, and delay the need for new sites. In order to assess these implications, the status of the existing landfill operations was reviewed and the system requirements and costs for two different disposal scenarios were studied, i.e.:

- 1) Landfill-based disposal system;
- 2) EFW-based disposal system.

The City presently disposes of its municipal waste at three landfill sites (Districts 2, 4 and 6) as shown on Figure 1.6. Two of the three landfills, District 2 and District 4, have limited capacity remaining. District 4 landfill will be full by 1990.

District 2 landfill operation raises environmental concerns regarding water pollution potential and a possible bird hazard related to the Winnipeg International Airport. This landfill could, however, continue in service for some time depending on the acceptability of the environmental risk.

The City has indicated that because of these factors, the District 6 landfill site will likely be incorporated into either one of the waste disposal systems considered in this study. District 6 landfill was therefore considered as an available site for both disposal alternatives. This would require the purchase of additional land.

TABLE 1.3
HAUL AND LANDFILLING COSTS
(1983 \$ million)

a) Landfill Based Alternative

Year	Haul Costs	Landfilling Cost	Total Cost
1990	4.10	3.46	7.56
1995	4.41	3.72	8.13
2000	4.96	3.84	8.80
2005	5.29	4.02	9.31
2010	5.67	4.25	9.92
2015	6.04	4.52	10.56
2019	6.33	4.74	11.07

b) EFW Plant Based Alternative

Year	Haul Costs	Landfilling Cost	Total Cost
1990	3.14	1.22	4.36
1995	3.37	1.33	4.70
2000	3.66	1.57	5.23
2005	3.98	1.79	5.77
2010	4.29	2.02	6.31
2015	4.57	2.18	6.75
2019	4.79	2.30	7.09

c) Avoided Costs with EFW Plant Based Alternative

Year	Haul Costs	Landfilling Cost	Total Cost
1990	0.96	2.24	3.20
1995	1.04	2.39	3.43
2000	1.30	2.27	3.57
2005	1.31	2.23	3.54
2010	1.38	2.23	3.61
2015	1.47	2.34	3.81
2019	1.54	2.44	3.98

Landfill-based Disposal System Costs:

With limited capacity at two of the existing landfill sites a new disposal site will be required if the landfill-based disposal system is continued. A number of sites were modelled by computer together with District 6 landfill in the landfill-based disposal alternative.

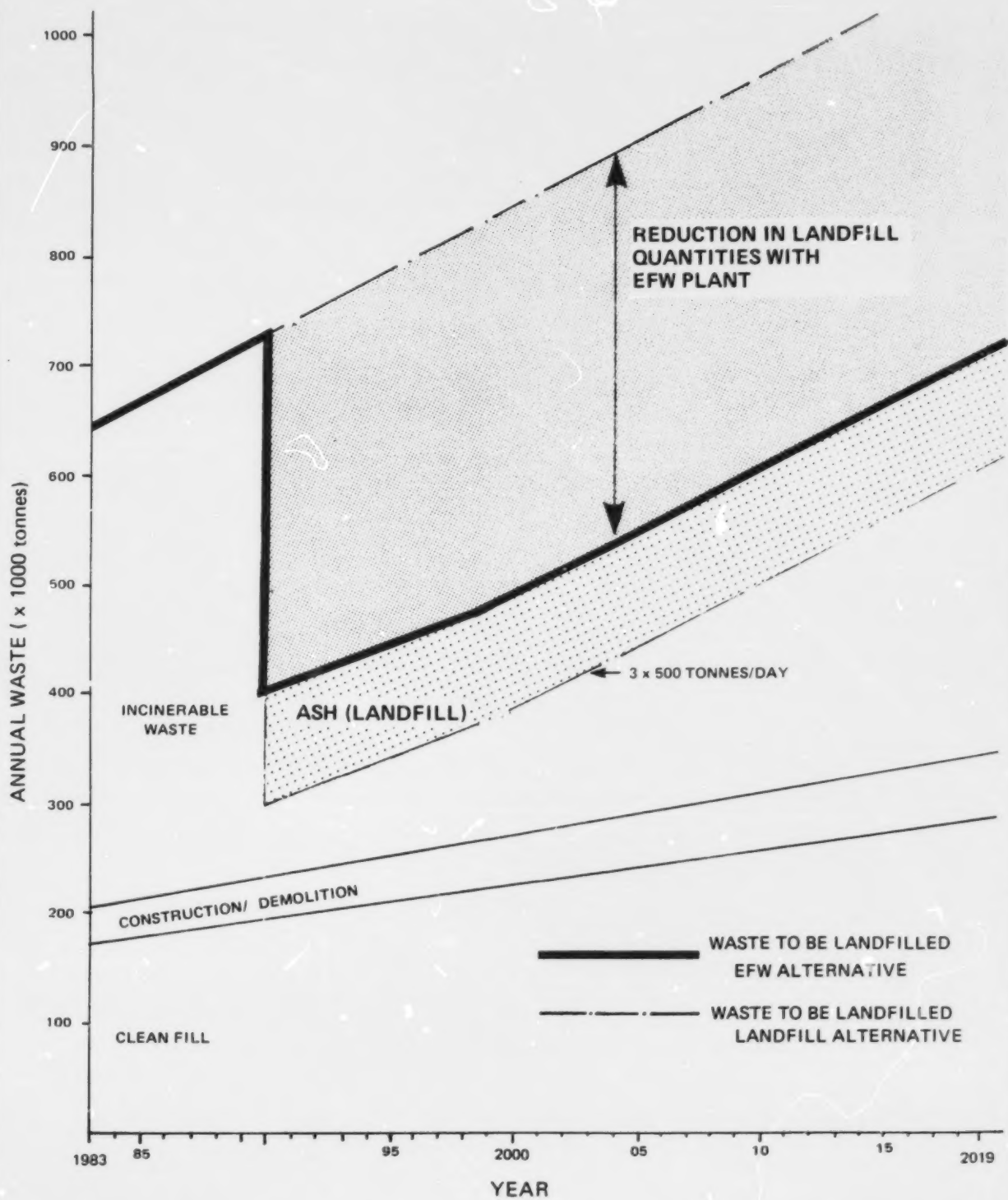
Table 1.3 a) gives the haul and landfilling costs (1983 dollars) which would be incurred with the landfill based alternative.

EFW Plant Based Alternative:

A centrally located EFW plant would reduce haulage costs. It would also reduce landfilling costs in proportion to the volume of waste incinerated less the quantity of ash produced. Ash produced by an EFW plant is approximately 10% of the volume of MSW incinerated.

A breakdown of the amount of solid waste taken to landfill with an EFW based disposal system is shown on Figure 1.7. The 1500 t/d EFW plant will burn 89% of the incinerable solid waste collected in the City of Winnipeg in 1990 and approximately 69% in the year 2019. It is evident that ash, construction and demolition waste, clean fill, and solid waste surplus to the capacity of the EFW plant, will result in substantial volumes remaining to be landfilled. Table 1.3b) gives the anticipated costs for haulage and landfilling for an EFW based disposal system.

Table 1.3 c) shows the estimated avoided costs resulting from the incorporation of an EFW plant in the MSW disposal system. From this table it can be seen that an EFW plant based scenario will result in avoided costs of \$3.2 million (1983) in 1990 and the avoided cost increases in later years.



CITY OF WINNIPEG - DISTRICT HEAT STUDY
LANDFILL QUANTITIES WITH
EFW - BASED DISPOSAL SYSTEM

FIGURE 1.7

1.3.1.4 Land Requirements

At the current rate (without an EFW plant), 250 ha of land, excluding buffer zones, etc., will be required to landfill the projected residential/commercial and industrial refuse quantities for the period 1990 to 2019. An EFW plant will reduce the land requirement to 90 ha (excluding buffer zones, etc.).

1.3.2 Auxiliary Fuels

Because winter steam demand exceeds the energy available from MSW, there will be a requirement for auxiliary fuels to meet demand during the colder months of the heating season. Thus, the availability and price of auxiliary fuels has been investigated in order to provide input into the economic analysis where required.

Current prices, specifications and availability of natural gas, oil, electricity, coal and waste oil, have been investigated as possible supplements to MSW for the generation of steam for an expanded Winnipeg Hydro district heat distribution system. It was determined that all these fuels except waste oil will be available in sufficient quantity for the limited needs of an EFW plant. Natural gas was chosen as the most suitable fuel due to plant design considerations, for start-up at the EFW plant and also for peaking fuel at the existing Amy Street plant.

It may be desirable to store some fraction of MSW (e.g. wood or plastics) during the summer for use in the EFW plant during periods of winter shortage. It is anticipated that this will be an operational decision and has not been taken into consideration in the economic analysis of an EFW facility.

1.3.3 Special Wastes

Since the provincial government is actively considering the establishment of a hazardous waste disposal facility in Manitoba, there is no requirement for an EFW plant to handle the more dangerous materials. The revenue available to an EFW plant for the disposal of the less hazardous special wastes which could safely be handled is minor, and would not justify the additional cost which could be incurred in the safe incineration of these materials. Consequently no provision is made in the EFW plant conceptual design for handling these special wastes. This decision could be reviewed at the detailed design stage of project implementation.

1.4

E.F.W. PLANT

A conceptual design has been developed for the energy-from-waste plant (EFW plant) which incinerates municipal solid waste (MSW) to produce steam for distribution to district heating system customers. This conceptual design formed the basis for development of capital and operating cost estimates for the facility. In developing the EFW plant design, many factors were considered and a significant number of alternative scenarios evaluated to arrive at an optimum plant arrangement.

The selected arrangement consists of three 500 tonne per day mass burning incinerator/boiler units capable of producing steam at 3000 kPa (420 psi) for distribution to district heating customers. During periods of low district heating demand, steam will be diverted to the existing Amy Street turbo-generators to produce electricity for sale. The existing No. 8 boiler at Amy Street will be converted to natural gas firing to supplement the output of the EFW plant during winter peak demand periods.

1.4.1

Conceptual Design Considerations

In arriving at the final conceptual design, many factors or considerations were reviewed as follows:

- Various EFW technology options were considered including mass-burning, semi-suspension and full suspension burning.
- Air pollution control systems of various types were reviewed.
- The district heating medium was selected.
- Electric Power generation by parallel generation and co-generation was evaluated.
- Required standby facilities were identified.
- Economic input data was developed for several different heating loads and plant sizes.

OPTIONS

- EFW TECHNOLOGY
- AIR POLLUTION CONTROL
- DISTRICT HEATING MEDIUM
- POWER GENERATION
- STANDBY FACILITIES

EFW PLANT SIZES

- 900 t/d
- 1200 t/d
- 1500 t/d
- 1800 t/d

MEDIUM
AND HIGH
PRESSURE

SELECTED EFW PLANT

- 1500 t/d
- LOW PRESSURE
- 1,394,000 GJ/a HEAT LOAD
- MASS BURNING INCINERATOR
- ABSORPTION - FABRIC FILTER
- STEAM DISTRIBUTION
- PARALLEL GENERATION
- AMY STREET AS STANDBY
- MILL STREET SITE

DISTRICT HEATING LOADS

- 787,000 GJ/a
- 981,000 GJ/a
- 1,394,000 GJ/a
- 1,796,000 GJ/a

STEAM AND
HOT WATER
HEATING

POTENTIAL SITES

- MILL ST.
- LOGAN - ELLEN
- GRACE ST.
- INCINERATOR
- DISRAELI
- LOGAN IND.
- MAN. BRIDGE
- RUE MESSIER

- Characteristics of solid waste generation (including quantities and distribution by month) and its heating value were considered.
- Eight sites were assessed for their effect on the plant design and its costs.

These factors are shown diagrammatically on Figure 1.8.

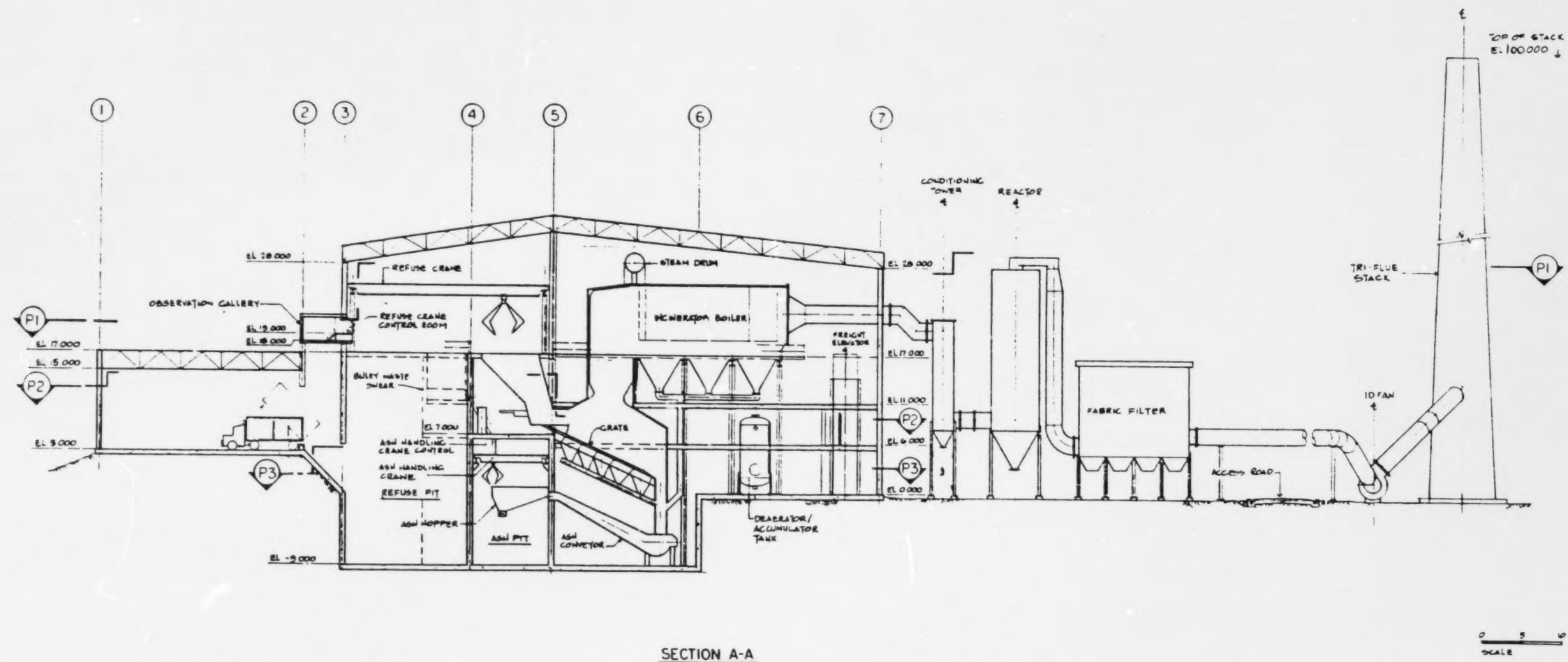
1.4.2 Selected Plant Description

1.4.2.1 Plant Size

A detailed economic analysis of the various system configurations determined that three incinerator/boiler units capable of incinerating 500 tonnes per day of MSW will be the most economical arrangement. The units will produce a total of approximately 200,000 kg/h (440,000 pounds per hour) of steam at 3000 kPa (420 psi) and 320°C (608°F). Each unit will operate 7500 hours per year and will be down for scheduled cleaning and maintenance for 1260 hours per year. The plant will burn 89% of the incinerable solid waste collected in the City of Winnipeg in 1990 and approximately 69% in the year 2019 at the end of its 30-year life. Figure 1.9 shows a cross section through the proposed plant.

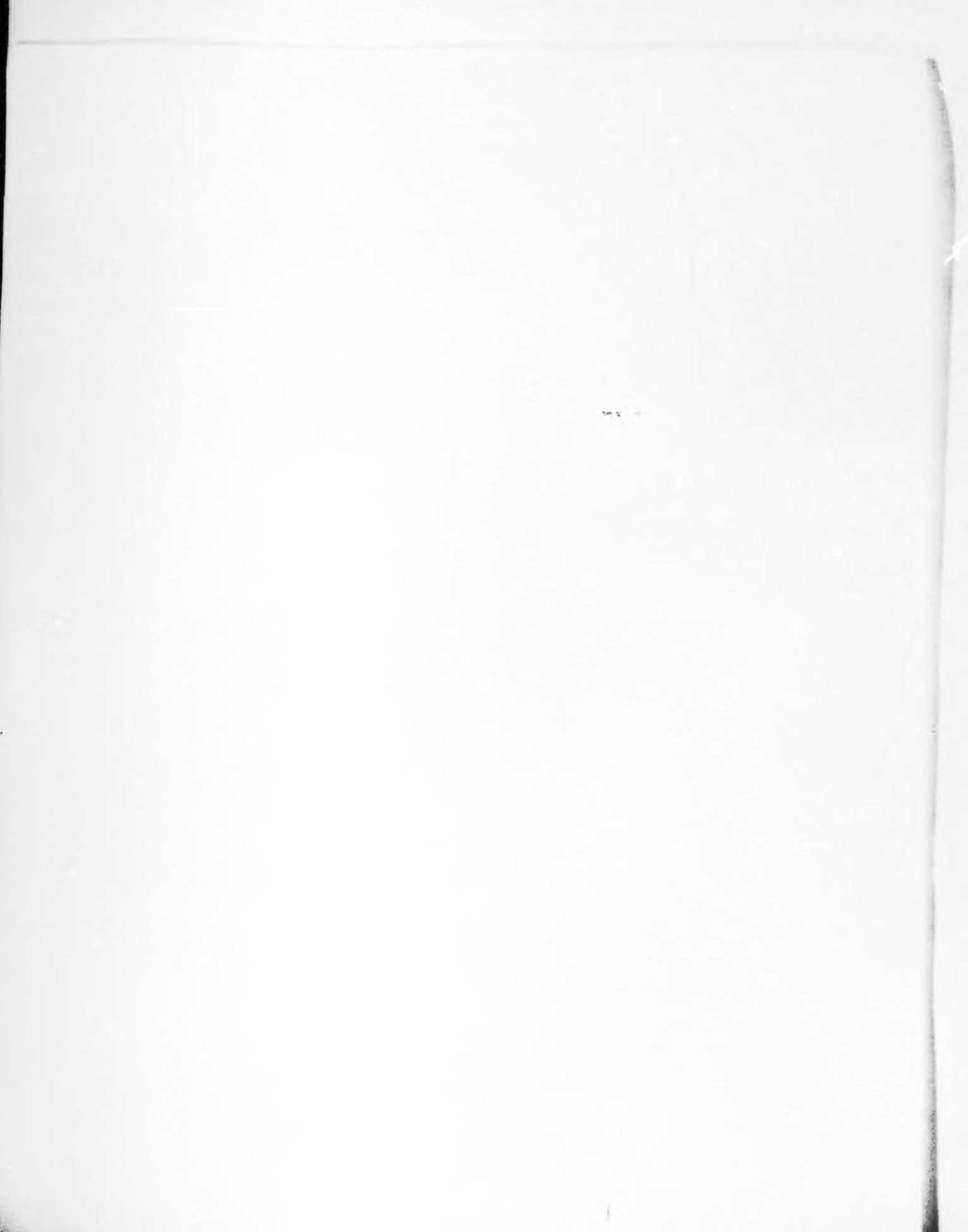
A 1500 tonne per day EFW plant will provide approximately 99% of the steam demand of the district heating system in 1990. Due to increasing volumes and heating value of MSW the EFW plant will be capable of producing 100% of the demand by the year 2006 and in subsequent years.

The projected increase in quantities and heating value of MSW far exceed the increase projected for heat demand. Consequently, confidence in the solid waste mass forecast is not a critical issue in this study.



CITY OF WINNIPEG - DISTRICT HEATING STUDY
1500 t/d EFW PLANT
LONGITUDINAL SECTION

FIGURE 1.9



1.4.2.2 Solid Waste Handling

Between 390 and 400 trucks per day will deliver M.S.W. to the EFW plant. The trucks will be weighed, proceed to an enclosed tipping hall and unload into slides leading to a refuse pit.

Solid waste will be moved from the refuse pit to the boilers using overhead travelling cranes which will also be used for mixing solid waste in the pit to provide for more uniform firing.

After delivery to the feed hopper the solid waste is fed to the boiler using a ram feeder.

1.4.2.3 Incineration

The solid waste will be burned on moving grates in the incinerator. As it moves on the grates from the charging hopper to the ash pit, the MSW releases its energy and is transformed into sterile ash.

Combustion air is drawn into the boilers from the tipping hall and refuse pit areas, resulting in a negative pressure in these areas. This ensures that any odour producing gases are drawn through the incinerator where they will be destroyed by combustion. The lower pressure in the tipping hall ensures that odours from the M.S.W. do not escape to the surrounding neighbourhood.

Controlling the temperature in the furnace is an important aspect of incineration technology. The temperature of the combustion gas will be maintained at a minimum of 800°C as it passes through the furnace. If lower temperatures were allowed, odours and smoke may leave the stack with the combustion gas, thereby creating air pollution and noxious odour problems. On the other hand, if the temperature of the combustion gas is over about 1,050°C, sufficient quantities of nitrogen oxides may form to create a different kind of

air pollution problem. At high temperatures, fly ash entrained with the combustion gas may become sticky and build up rapidly on the heat transfer surfaces in the boiler, thereby interfering with its steam production efficiency.

To keep the temperature of the combustion products as they leave the grate enclosure between 900°C and 1000°C, waterwalls protected with plastic refractory are installed on the sides and roof of the grate enclosure to absorb some of the heat released by the burning solid waste on the grates. Waterwalls consist of boiler tubes parallel to one another.

The hot combustion products from the grate enclosure flow through the radiation furnace which is also lined with waterwalls. The gas then flows through the superheater, the evaporator and the economizer section, where boiler feedwater is heated as it first enters the boiler and the gas is further cooled, to between 230°C and 270°C, as it leaves the boiler on its way to the flue gas cleaning system.

The control room is the EFW plant operations centre. The entire process can be controlled and monitored from this room. Devices are installed in the control room for automatically controlling such variables as the solid waste feeder cycle time and stroke length, individual and group speeds of the grate sections and damper settings for combustion air supplied to the grates. Manual overrides for adjusting critical variables are also located in the control room and at the equipment itself for the operators in the plant. Dials, gauges, instruments and alarms in the control room reflect performance of the grates, boilers, feedwater system, air pollution control system and other major process systems in the plant. A picture of the fire on each grate is continuously displayed on television screens in the

control room. Measurement of the combustion gas temperature as it passes through the system and of the opacity and oxygen and carbon dioxide contents of the combustion gas as it passes through the stack are continuously taken, displayed and monitored by alarms in the control room.

1.4.3 Flue Gas Cleaning Process

The proposed emissions control system will consist of three independently operating, parallel lines each intended to service one furnace. The system will include evaporative cooling towers, dry absorption reactors, fabric filters, dust handling and treatment, and a computerized control system.

The evaporative cooling tower further reduces the temperature of the flue gas. The dry absorption reactor neutralizes and retains acidic substances such as hydrogen chloride, hydrogen fluoride and sulphur dioxide. The fabric filters remove fly ash and dust particles and any absorbent carried over from the reactor.

The flue gas cleaning process is monitored by a computerized controller which is programmed to make necessary decisions and adjustments and to display information and alarms based on equipment and process conditions within the system.

The flue gas cleaning process will be designed to condition the flue gas so as to meet the most stringent environmental regulations, and will provide emissions control in excess of any current Canadian requirements.

1.4.4 Facilities at Amy Street

The Amy Street plant will continue to play a major role in a Winnipeg district heat system and will be integrated with the EFW plant via interconnecting pipelines. Amy Street will continue to be the focal point for the distribution of steam to the existing district heating network. No. 8 boiler will be converted to natural gas firing to provide the additional steam required to meet winter peak demands and to provide standby steam generating capacity in order to ensure overall system reliability. The Amy Street turbines will be used to generate electricity from surplus steam during periods when heat demands of the district heating network are low.

By converting No. 8 boiler to gas firing, the requirement for installation of pollution control equipment will be eliminated. With elimination of coal firing, the appearance of the plant will be improved by removal of the present coal storage piles.

1.4.5 Cost Estimates

1.4.5.1 Capital Cost

Cost estimates have been based on prices in mid-1983, with import duty, provincial sales and payroll taxes included where applicable. EFW plants are exempt from Federal Sales Tax. The accuracy of the estimates is considered to be within +12% and -5% for the EFW plant and +15% for the balance.

The overall capital cost summary, including the steam distribution system is as follows:

<u>Item</u>	<u>Estimated Cost \$1000 (1983)</u>
Land and Site Cost	3,070
1500 t/d EFW Plant	81,190
Initial Distribution Network	10,258
Amy Street Facilities	<u>880</u>
	95,398
Engineering, Commissioning	7,471
Contingency	<u>5,215</u>
Total up to 1990	108,084
Replacement of Existing Distribution System	9,000
Future Connections	<u>1,652</u>
Total up to 2019	118,736

1.4.5.2 Operating Costs

The operating cost of an EFW plant and ancilliary facilities will vary slightly over the years.

Projected operating costs are summarized below. Cost of capital is not included in these figures.

<u>Item</u>	<u>Year</u>		
	<u>1990</u>	<u>1991</u>	<u>2019</u>
EFW Plant Fixed Costs	3,696	3,696	3,696
EFW Plant Variable Costs	260	262	281
Auxiliary Fuel	99	100	5
Electricity Purchased	518	487	411
Amy Street Plant Operation	600	600	600
District Heating Network	570	570	570
Customer Connections	<u>50</u>	<u>50</u>	<u>43</u>
	5,793	5,765	5,606

TABLE 1.4

SUMMARY OF HEAT LOADS
(1990)

<u>Heat Load</u>	<u>Annual Consumption GJ</u>	<u>Maximum Heat Demand GJ/h</u>
. Existing Downtown System	422,000	216.0
. Provincial Government	85,350	34.8
. Canadian Pacific	67,500	36.9
. Health Sciences Centre	606,625	216.2
. Other Loads	<u>212,180</u>	<u>86.5</u>
TOTAL CONNECTED LOAD	1,393,655	590.4

1.5 DISTRIBUTION NETWORK

On the basis of the market analysis carried out, the most likely prospective customers for a district heating system were identified. Of course, the customer list may change prior to the final system being installed. However, this list was used as the basis for the design and cost estimating for a new distribution network. Integration of the new network with the existing steam distribution system has been studied.

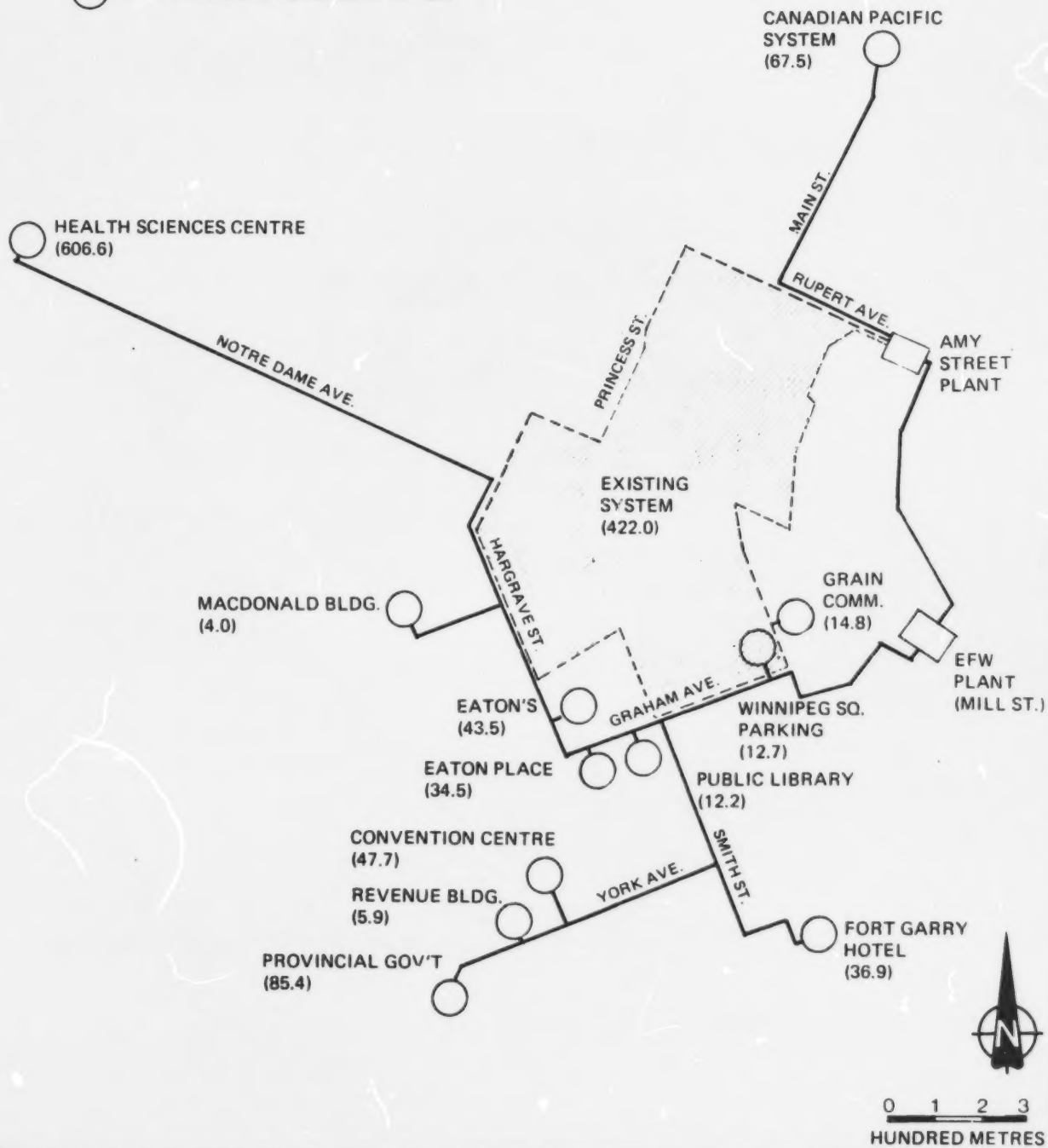
1.5.1 Heat Load Definition

In order to develop a distribution system layout to allow sizing and cost estimating, an assumption regarding prospective customers was necessary. In this report, Part 2 - Market Prospects, the most likely heat loads in 1990 (on system start-up) were identified. The projected load growth over the 30-year study horizon was also defined. The 1990 load will be approximately 1.4 million gigajoule per year growing to 1.56 million gigajoule per year by the year 2019. The opening day load assumption is shown on Table 1.4. This table includes those loads which were assessed in the marketing work to have the highest probability of connecting to an expanded district heating system. Until contracts with customers are signed these loads remain an assumption. However, it is the most logical assumption under present circumstances. It is probable that at least some of these customers will not sign contracts, however others not presently included in the list may decide to purchase heat from the system. The distribution network and its costs derived from this assumption are sufficiently large that some change in actual customers can be accommodated without adversely affecting project economics.

----- OUTLINE OF EXISTING DOWNTOWN STEAM LOOP

———— PROPOSED NEW STEAM DISTRIBUTION LINES

○ NEW LOADS (ANNUAL HEAT 10^3 GJ)



CITY OF WINNIPEG - DISTRICT HEAT STUDY
STEAM DISTRIBUTION NETWORK
SCHEMATIC

FIGURE 1.10

1.5.2 Distribution Configuration

Since the largest part of the identified new heat load can only use steam as a heat carrier, and because the existing downtown system is based on steam, the heat carrier selected for this system is steam.

Three major new loads result in the new distribution network taking on a radial as opposed to a grid type of configuration (Figure 1.10). All of these loads are outside the area served by the existing distribution network. These major loads are:

- The Health Sciences Centre located North-West of the present system.
- The Provincial Government complex located South-West of the present system.
- The CP Rail facilities located North-East of the present system.

A major part of the load is fed from the line to the Health Sciences Centre. From the EFW plant located on the Mill Street site, the pipe will be located on Graham Avenue at the south side of the existing system. It will travel north on Hargrave Street to Notre Dame Avenue and then west on Notre Dame to the Health Sciences Centre.

The line to the Provincial Government complex will tee off the line to the Health Sciences Centre on Graham Avenue and travel south on Smith Street to York Avenue and west on York Avenue to connect to the Provincial Government system near Vaughan Street.

It is proposed that the C.P. Rail facilities be serviced by a new line from the existing Amy Street steam plant travelling west on Rupert Avenue and north on Main Street.

These routes have been chosen as the basis for the conceptual design and cost estimate. During detailed design, other routes would be considered to minimize traffic disruption and potential conflicts with existing underground installations.

The Amy Street steam plant will remain as the distribution centre for the existing distribution system.

In the future, the entire existing downtown system could be surrounded with new feeder pipes by extending the line on Rupert Avenue to Princess Street and down Princess Street to tie into the feeder to the Health Sciences Centre on Notre Dame Avenue. This would allow pressure "flooding" of the older system on its perimeter and would dramatically increase the amount of load which can be served in that area.

The entire new distribution system will be 6.8 km in length. This compares to the existing network composed of 9 km of piping.

Condensate will be recovered from many of the larger new heat loads. This will reduce capital and operating costs of the make-up water system at the EFW plant and will enable the system to sell more heat in the winter. Adding condensate recovery to the existing downtown system is not recommended as the benefits do not justify the cost and inconvenience involved to install the necessary modifications.

The conceptual design of the new network provides capacity for future expansion by oversizing of pipes in those areas where load growth is anticipated. Equipment and materials will also be selected to accommodate an increase in temperature and pressure if required.

Steam mains will be insulated carbon steel pipes enclosed in an aluminum jacket and placed in pre-cast concrete utilidors which will be buried below the Winnipeg street system. The pipes will be designed to allow for expansion and access to the system will be gained through manholes. The manholes will contain the necessary isolation valving as well as expansion joints. Condensate return lines of filament wound epoxy pipe will be run external to the concrete utilidor. Special care will be required to avoid damage to the pipes where they pass through manholes; the pipes in the existing system have been damaged by road salt.

1.5.3 Customer Connections

The premises at each major heat load have been inspected to determine the required connection arrangement. Generally, each load requires a take-off from the street main consisting of piping, fittings and shut-off valves. These are provided by the district heating company.

Inside the premises, control valves, safety and metering devices, pressure gauges, thermometers, etc. are required to properly serve the customer with district heat and to charge for the heat delivered. This equipment could include a steam to hot water heat exchanger and associated controls for customers with hydronic heating systems. All or a part of the terminal equipment may be provided and maintained by the district heating company, subject to the terms of the supply contract.

Estimates prepared for the distribution network include an allowance for connection and terminal facilities at each of the new customers premises.

1.5.4 Existing Distribution Network

An inspection and analysis of the existing distribution system was performed. The inspection was limited to inspecting piping opened for repairs or maintenance and examination of piping which had been removed from the system. Historical data on pipe repairs was also obtained from Winnipeg Hydro.

Generally, the interior of the piping system has experienced very little deterioration. Pipe failures were mainly attributed to external corrosion. Only 5% of the system has been replaced. It is impossible through current non-destructive testing methods to determine the remaining life span of the piping.

It has been assumed that in order to continue to serve existing clientele that the entire existing system will be replaced over the first 10 years of the system's operation. Allowance has been made for this replacement in the cost estimates.

1.5.5 Cost Estimates

Capital costs have been estimated as follows:

	(\$ x 1000) 1983
- <u>New Distribution Network</u>	
• Civil works	\$ 4,552
• Piping, mechanical and insulation	4,728
• Customer connections (terminals)	417
• Engineering, contingency, etc.	1,649
• Total	<u>\$11,346</u>
- <u>Existing System Rehabilitation</u>	
• Total estimated replacement	\$12,398
• <u>Less Portion replaced by</u> new distribution network	<u>2,533</u>
Difference	9,865
• <u>Less Savings for improved design,</u> smaller pipes, etc.	<u>865</u>
Net Rehabilitation Cost	<u>\$ 9,000</u>

This amount is projected to be spent over 10 years (1990-2000).

In addition to these costs, \$1,652,000 (1983) has been allowed to cover the cost expected to be incurred for connecting future customers to the system.

The annual operating cost for the complete distribution network has been estimated at \$570,000.

1.6 ENVIRONMENTAL AND SOCIO-ECONOMIC CONSIDERATIONS

Environmental and socio-economic considerations associated with the operation of an EFW facility were reviewed to determine if major impediments existed to implementing an energy-from-waste (EFW) district heating system. The impacts of an incinerator with a design capacity of 1500 tonnes of municipal refuse per day at the preferred Mill Street site were the principal focus of this review. Impacts of EFW plants with combustion rates ranging from 1200 to 1800 tonnes/day and located at various sites were evaluated. It has been concluded that the recommended facility can be operated with no significant adverse impact on the environment.

1.6.1 Environmental Considerations

Environmental concern is one factor likely to influence project feasibility. Potential environmental concerns relating to an EFW plant centre on plant effects on the ambient environment (e.g., stack emissions, road dust, noise, etc.) of which impacts of emissions to the air environment are considered the major potential environmental effect. Of additional interest are concerns regarding wastewater management and disposal (including thermal loading to the Red River), disposal of residual ash, increased traffic, aesthetic and land use impacts, and public concerns about an incinerator located in an urban area. Site-specific aspects of these impacts exist, especially with regard to impact mitigation, (e.g., site-specific differences in stack height required to meet ambient air protective criteria).

1.6.1.1 Air Environment

Stack Emissions:

The proposed EFW plant will emit three classes of pollutants to the air environment, which are presently regulated by Provincial and Federal agencies, i.e. oxides of nitrogen (NO_2) and sulphur (SO_2) and suspended particulate (SP). Provincial and Federal air quality objectives are designed to provide protection for public health, soils, water, vegetation, animals and physical structures. In addition to these three regulated classes of pollutants, project emissions will also include hydrogen chloride (HCl) and dioxins (including furans). Neither HCl nor dioxins and furans are presently regulated by Manitoba, however provisional guidelines have been adopted in Ontario. Manitoba is considering the need to establish similar criteria. On this basis, the study addressed the significance of these currently-unregulated project emissions, relative to the Ontario provisional guidelines, because recent experience elsewhere in Canada, the United States, Europe and Japan indicates these contaminants raise a great deal of environmental concern.

Dispersion of project emissions of these compounds within the atmosphere was simulated using proven mathematical models accepted for such use by the Province, the US EPA and the Ontario Combined Hearings Board. The models utilized a ten-year data base of Winnipeg meteorological conditions to simulate short and long-term ground level emission concentrations and to predict short-term concentrations at elevated receptors (i.e., high-rise buildings near candidate sites). The simulations were conducted assuming a pollution control system consisting of lime conditioning towers and baghouses. This is considered "state-of-the-art" technology for maximizing containment of all pollutants, including heavy metals, dioxins and furans, and neutralization of acidic gases (HCl and others). The current

TABLE 1.5

SUMMARY OF MAXIMUM GROUND LEVEL CONTAMINANT CONCENTRATIONS
FROM THREE EFW PLANT SIZES

(Assuming a 91 m (300') stack height)

Contaminant	Average Time	3 x 400		3 x 500		3 x 600		Protective Criterion ($\mu\text{g}/\text{m}^3$)*	Measured Air Quality Downtown**** ($\mu\text{g}/\text{m}^3$)	
		t/d	t/d	t/d	t/d	t/d	t/d		Maximum	Mean
Suspended Particulates	1/2 hr	3.65	4.10	4.54	100	n/a***				
	24 hr	0.65	0.73	0.80	120	295				
	annual	0.049	0.054	0.058	70	50				
SO ₂	1 hr	25.1	28.2	31.2	900	225				
	24 hr	6.1	6.8	7.5	300	30				
	annual	0.46	0.51	0.55	60	0				
NO ₂	1 hr	30.2	33.8	37.4	400	190				
	24 hr	7.4	8.2	9.0	200	70				
	annual	0.55	0.61	0.66	100	25				
HCl	1/2 hr	11.0	12.3	13.6	100	not measured				
Dioxins**	1/2 hr	318	357	395	450**	not measured				

* $\mu\text{g}/\text{m}^3$ - micrograms (1 millionth of a gram) per cubic metre

**picograms per cubic metre - one trillionth of a gram per cubic metre.

***n/a - not applicable

****Source: (NAPS) National Air Pollution Surveillance Program
conveyed by Pers. Communication David Bezak,
Manitoba Environmental Management Division 84.07.24

Manitoba objectives could be met with less costly pollution control equipment consisting of lime conditioning towers and 3-stage electrostatic precipitators. However, in order to assess project viability under conditions where the project is required to minimize environmental impacts, the more costly system was incorporated into the plant conceptual design.

Dispersion modelling predicted short-term (1/2 or 1 hour), daily, and annual average concentrations for each pollutant of interest. All predicted concentrations were compared with protective ambient air criteria promulgated by the Province of Manitoba. Where Manitoba had no protective criterion (e.g., total dioxins and furans), an Ontario provisional guideline was used. Ontario is the only Canadian province to have promulgated advisory guidelines for the control of total dioxins and furans emissions. In addition, Ontario's provisional HCl guideline is very conservative, affording substantial environmental protection.

Short-term (1/2-hour, 1-hour) maximum concentrations at the points of impingement on the highest buildings in the study area (Richardson Building, Commodity Exchange Tower, The Delta Inn) were predicted to be well below all protective criteria for a 1500 tonne/day EFW plant with a 100 m stack operating at the preferred Mill Street site. Maximum concentrations for these elevated receptors were also well below all protective criteria for this plant operating at the Disraeli Street candidate site with a 100 m stack and at the rue Messier candidate site with an 38 m stack. Average daily and annual predicted concentrations at both elevated and ground-level receptors (Table 1.5) were also well below all protective criteria.

Dispersion modelling predicted that an EFW plant will increase the levels of the modelled contaminants in ambient air only very slightly above existing levels. Because an EFW plant will replace the existing coal-fired Amy Street plant and a number of other private oil- and gas-fired plants, operation of an EFW facility will reduce the current particulate burden in downtown Winnipeg air. The predicted concentration of particulates from an EFW plant is approximately 1% of the concentrations simulated for the existing coal-fired heating plant at Amy Street under current conditions. Reductions in particulate loading in the ambient air are a significant environmental and social benefit, because the downtown and stockyard areas are presently subjected to particulate levels which frequently exceed protective criteria.

Noise and Odour:

Other potential project impacts include plant-related noise and plant odours. During normal operations of the EFW plant, noise will be generated by in-plant equipment and by refuse trucks arriving at and leaving the site. The complete enclosure of the EFW refuse receiving and handling area will reduce the noise impact of the plant. The dumping bay under the receiving area will be maintained under negative pressure, so odours from fresh waste will be drawn into the incinerators, not back out of the building. The organic vapours causing odours will be consumed with combustion air. Perimeter berms, attractive landscaping, and a well-planned site layout can provide for further noise attenuation and visual screening. Experience with EFW facilities elsewhere in Canada, the United States and Europe indicates noise and odour emissions are not operating problems because of such design features.

Approximately 400 trucks per day will delivery MSW to the EFW plant. Based on a 14-hour day, this results in an average of 28 trucks per hour arriving at the site. Increased EFW-related traffic should pose no significant problem, because incremental truck traffic amounts to only a 2-4% increase over existing traffic volumes on truck routes adjacent to any of the candidate sites.

1.6.1.2 Water Environment

Wastewater:

Wastewater management and disposal is of environmental interest. However, because the plant wastewater and drainage will be taken to the City sewage treatment plant by existing combined sewers, no public water pollution concerns should exist. The plant would operate to meet City Bylaw No. 505/73.

Thermal Impact:

Water from the Red River will be used to cool existing turbogenerators at the Amy Street plant when these units are used to generate electricity from surplus EFW steam during the summer. Temperature increases in the river are of concern with respect to the protection of aquatic life. Maximum predicted temperature increase at the head of the mixing zone near the cooling water outfall to the river is 6.7°C. Maximum predicted increase based on complete mixing with the average 7-day and 10-year minimum flow in the Red River is 1.2°C. Surface Water Quality Objectives (1980) proposed to restrict average temperature increases to 1°C under these flow conditions, however, these Objectives are under review. Mitigation measures, if required, could include reductions in generator operations at sensitive times for aquatic life in the Red River. At these times additional solid waste could be diverted to existing landfills or a part of the steam condensed in the air cooled balancing condensers. As this is an infrequent occurrence, the impact on project economics is expected to be negligible.

1.6.1.3 Soil Environment

The disposal of odourless, sterile ash residue from an EFW plant can be safely carried out at the District #6 landfill site. Heavy metals and dioxins trapped in fly ash by the baghouse will be completely contained in the landfill. This landfill is located in a deep layer of highly-impervious clay which prevents percolation of any landfill leachate. The incinerator ashes produced typically generate leachate of minimal contamination once landfilled, due to the thermal decomposition of any toxic compounds present during combustion. In addition, the incineration process oxidizes virtually all organic material present in the refuse, producing an inorganic ash. Being inorganic, the potential for subsequent decay of ash in the landfill is virtually non-existent, precluding any possible generation of methane. As a consequence, the total methane generation potential of a landfill receiving EFW ash along with other putrescible refuse is considerably reduced.

1.6.2 Socio-Economic Impacts

Two types of socio-economic impacts have been considered; direct impacts, and the more indirect and difficult to quantify, "economic multiplier effects." There are direct socio-economic benefits associated with employment during the short-term construction phase of the project and during the long-term operating phase. Economic multiplier effects apply more to the long-term operation of the facility.

1.6.2.1 Short Term Effects

Construction employment on the EFW project would peak at about 400 and would average about 250 over a 3-year period. This employment may be considered "new" employment as it is not replacing any other source of employment. The 750 man-years of employment which would be created by the construction of the EFW plant (and steam distribution system) is clearly a major socio-economic benefit of the project.

Construction of the plant would also generate secondary employment in the manufacturing sector, in terms of equipment and materials supply. The actual number of man-years of secondary employment created locally is difficult to predict as it is dependent on the capacities and employment situation in the relevant local industries at the time.

In dollar terms, the benefit of the total investment in construction of the EFW plant and the distribution system would not all accrue to the local (Winnipeg/Manitoba) economy. A rough estimate of the local input is \$50,000,000 or about 50% of the total investment, which represents a sizeable benefit to the local construction, manufacturing, and engineering industries.

1.6.2.2 Long Term Effects

In the long term, the EFW plant operating staff is estimated at 70 with a total annual payroll of \$1 884 000. The number presently employed at the Amy Street plant is approximately 60. If the EFW project proceeds, the number employed at Amy Street will reduce to approximately 20. The total employment associated with the new district heating system is therefore 90 with a net gain of 30 jobs.

During market interviews, owners of buildings with existing heating plants indicated that present operating staff would be retained to carry out other assigned duties. Consequently job loss is not anticipated as a result of the conversions to district heating.

However, in comparing the long-term employment benefits of the EFW project with the "no-go" scenario including termination of the Amy Street operation, the net effect is a gain of 90 jobs, i.e., 30 new jobs created compared to a loss of 60 jobs.

The 30 new permanent jobs generated by the plant would be expected to generate service sector jobs in the ratio of about 1:1.5 for a total long-term job creation of 45 jobs or 1350 man-years of employment. All things considered, it may be concluded that the district heating system would have definite long-term employment benefits but not large benefits.

1.6.2.3 Other Benefits

There are other potential benefits associated with the EFW project. The project will provide a positive contribution to the development of the downtown area in terms of a reliable and competitively priced energy source.

The project may be particularly important for older downtown buildings suitable for renovation but not easy to retrofit with heating systems other than steam.

The project will demonstrate an innovative blending of state-of-the-art technology with sensitive urban design. The plant will represent a significant architectural enhancement to the urban environment, including upgrading of the downtown riverbanks.

The project will also represent a public commitment to environmentally sound energy conservation with state-of-the-art pollution control measures meeting the appropriate standards.

Perhaps the most important social benefit of the EFW project lies in the utilization of society's waste as an energy source thereby reducing dependence on fossil fuels.

1.7 SITE SELECTION

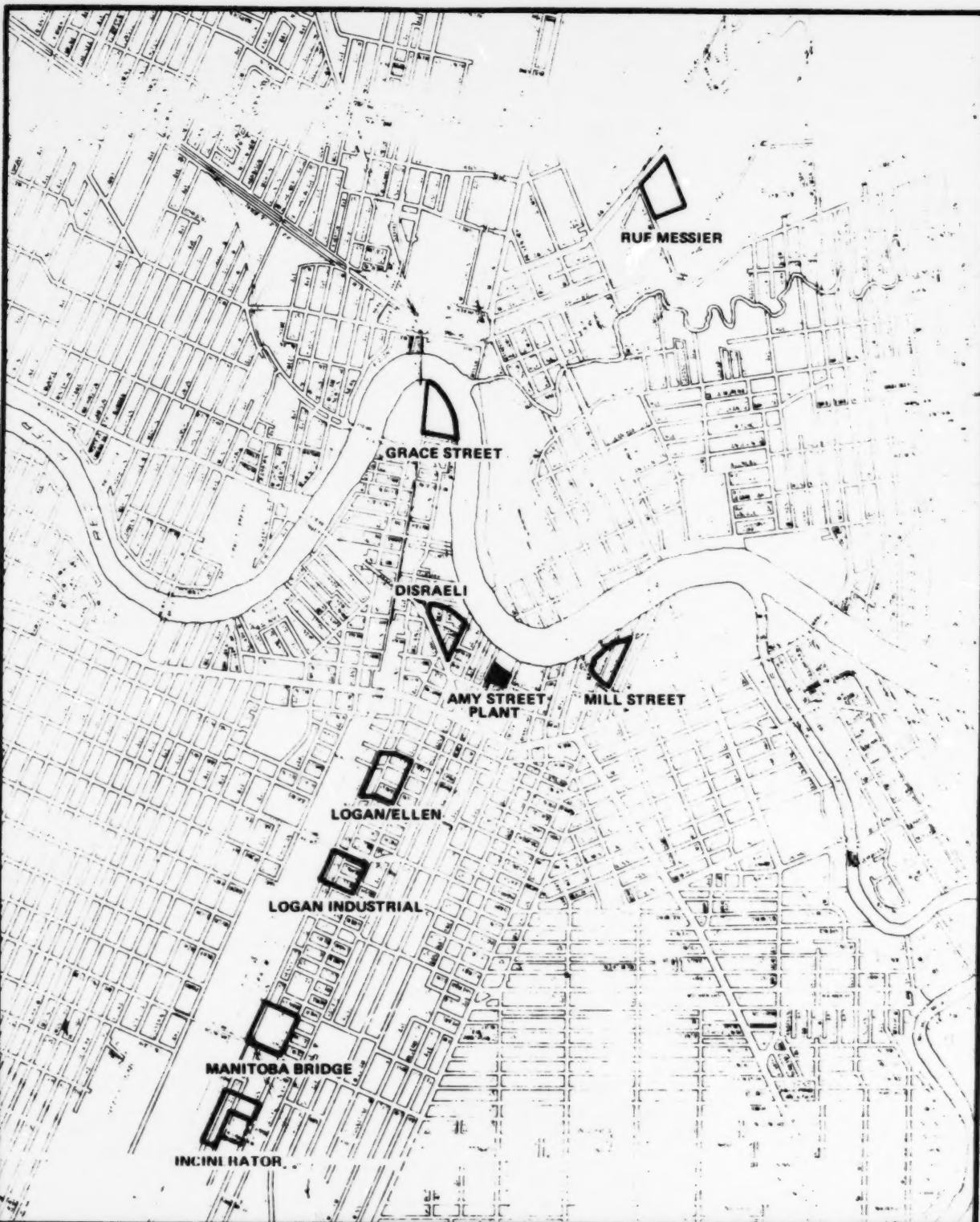
1.7.1 Methodology

The site selection process has two aspects. The first entails rating a number of candidate sites against a set of environmental and public acceptability criteria. The criteria represent the effects or impacts which the EFW plant may have on the environment and on the community. The relative impact of each candidate site can then be compared on the basis of the ratings. The second aspect of the site selection process entails comparing the candidate sites on the basis of cost, since there are significant site specific costs which vary with plant location.

The preferred site is the site which is judged to strike the best balance between environmental/public acceptability, and cost.

There are six basic steps in the site selection process:

- . Identify a range of possible areas for plant location;
- . Apply fundamental land use and engineering criteria;
- . On the basis of these criteria, identify a number of candidate sites;
- . Rate each candidate site on the basis of more detailed environmental/public acceptance criteria;
- . Estimate site specific costs;
- . Select preferred and alternate sites on the basis of environmental/public acceptance criteria and site specific costs.



CITY OF WINNIPEG - DISTRICT HEATING STUDY

CANDIDATE SITES



FIGURE 1.11

1.7.2 Candidate Sites

For the Winnipeg EFW plant, eight candidate sites were identified. The sites ranged from centrally located in the downtown area to locations up to four kilometers from the downtown core. The candidate sites were as follows (see Fig. 1.11):

Mill Street, bounded by Pioneer Avenue, the CNR main line and the transfer track paralleling the west bank of the Red River;

Disraeli, bounded by George Avenue, the Disraeli Freeway, the transfer track along the west bank of the Red River and May Street;

Logan/Ellen, bounded by Logan Avenue, Stanley Street, Ellen Street, and Higgins Avenue;

Incinerator, which is the site of the old City of Winnipeg Incinerator at Henry Avenue and Maude Street;

Rue Messier, south of the intersection of Rue Messier and Dawson Road;

Logan Industrial, bounded by Logan Avenue, Isabel Street, Gunnell Street and Higgins Avenue;

Manitoba Bridge, bounded by Logan Avenue, Arlington Street, Tecumseh Street and Higgins Avenue;

Grace Street, bounded by the rear of the properties fronting on Grace Street, the CPR main line, and the Red River.

1.7.3 Site Selection Criteria

A total of sixteen environmental and community impact criteria were utilized in rating these sites under the broad categories of land use, transportation, environmental, and general public acceptance. The site selection criteria were as follows:

Land Use:

- Existing land use at site
- Ease of acquisition
- Compatibility with existing adjacent uses
- Compatibility with future/proposed adjacent uses
- Potential for expansion
- Influence on future land use

Transportation:

- Traffic volumes on the regional street system
- Traffic volumes adjacent to the site
- Proximity to arterial routes

Environmental:

- Archaeological
- Stack emissions/air quality
- Thermal discharge to water

Public Acceptability:

- Aesthetics/visual impact
- Isolation of site
- Traffic nuisance
- Community disruption

A measure was established for each criteria, the sites rated accordingly and the ratings reduced to a common 1-10 scale.

1.7.4 Criteria Weighting

Because the ratings represent different types of environmental or public acceptance effects, they cannot simply be added together to arrive at a total rating; instead, each impact rating must be multiplied by a weighting factor which represents the relative importance of that impact.

For this Study a panel of individuals with different backgrounds and not directly associated with the project established weighting numbers. The process of generating the weighting numbers took the following form:

The objectives of the site selection program and the issues involved in selecting the preferred and alternate sites were thoroughly discussed with the members of the panel. The different site selection criteria, environmental effects and their significance were described by members of the study team. Each panel member was asked to give his or her opinion on the relative importance of each site selection criteria or type of impact by distributing weighting points among the criteria. The panel members then discussed their initial point distributions and further discussed the criteria. After the first set of weightings were thoroughly reviewed, the panel members distributed their weighting points again, arriving at a reasonable consensus on weighting numbers for each criteria. In general the panel members were in close agreement on those impacts which they considered most important; less in agreement on those impacts which they considered of lesser importance.

TABLE 1.6
SITE SELECTION MATRIX
(SUMMARY)

<u>Criteria</u>	<u>Relative Weight</u>	<u>Weighted Ratings</u>				
		<u>Mill St.</u>	<u>Disraeli</u>	<u>Grace St.</u>	<u>Man. Bridge</u>	<u>Incinerator</u>
Land Use	9.6	4.5	5.7	3.2	4.4	4.4
Traffic	6.4	2.2	2.8	3.0	3.6	3.6
Environmental	7.4	6.4	5.0	5.7	2.9	2.9
Public Acceptance	8.3	3.9	7.2	2.9	4.5	4.5
TOTAL SCORES		17.0	20.7	14.8	15.4	15.4
						11.3
						0.4
						3.7
						4.8
						2.4

Note:

- 1) This table is a summary of the full site selection matrix which appears as Table 7.3 in Part 7.
- 2) Lower weighted ratings indicate a more desirable site from an environmental/public acceptance perspective

1.7.5 Site Scores

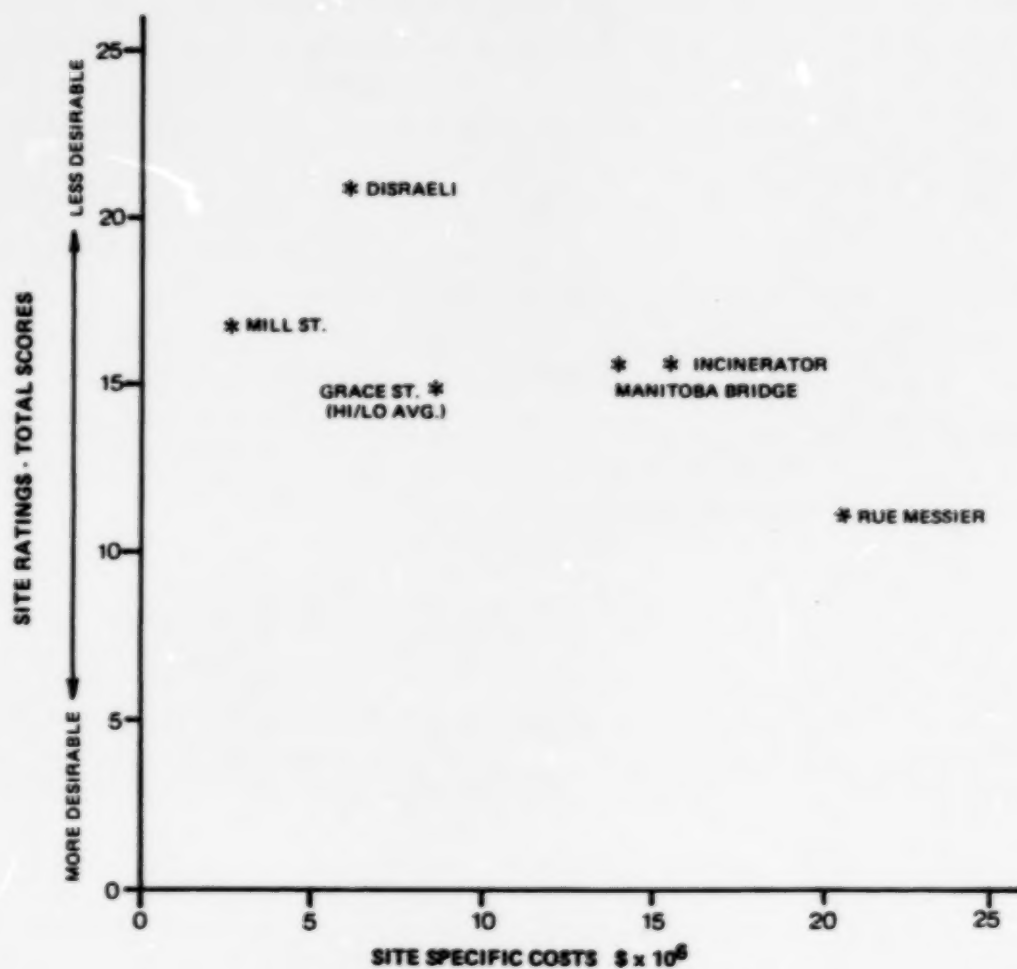
The environmental/public acceptance "score" for each candidate site was determined by weighting the individual ratings, utilizing the weighting numbers generated by the panel and summing the weighted ratings for each site in a site selection matrix. (The Logan/Ellen and Logan Industrial sites were eliminated from consideration when it was learned that they were both dedicated or planned for a specific future land use.)

Table 1.6, titled Site Selection Matrix, is a summary of the full site selection matrix which appears as Table 7.3 in Part 7. A detailed explanation of the method of numerical weighting and scoring in the site selection matrix is also provided in Part 7 (Section 7.4, Site Selection Methodology). In the summary table only the main categories of site selection criteria are shown with the final weighted scores for the candidate sites.

The total scores, as shown in Table 1.6 range from a low (best) score of 11.3 for the Rue Messier site to a high (worst) score of 20.7 for the Disraeli site. The remaining four candidate sites all score within a fairly narrow intermediate range between 14.8 and 17.0.

1.7.6 Site Specific Costs

Site selection depends on economic factors as well as environmental/public acceptance comparisons. In the case at hand, several of the candidate sites could be considered "acceptable" although with varying degrees of impact.



CITY OF WINNIPEG - DISTRICT HEATING STUDY
SITE SELECTION
SITE RATINGS VS. SITE SPECIFIC COSTS

FIGURE 1.12

Following are the site specific costs associated with the EFW plant which were taken into account in selecting the preferred site.

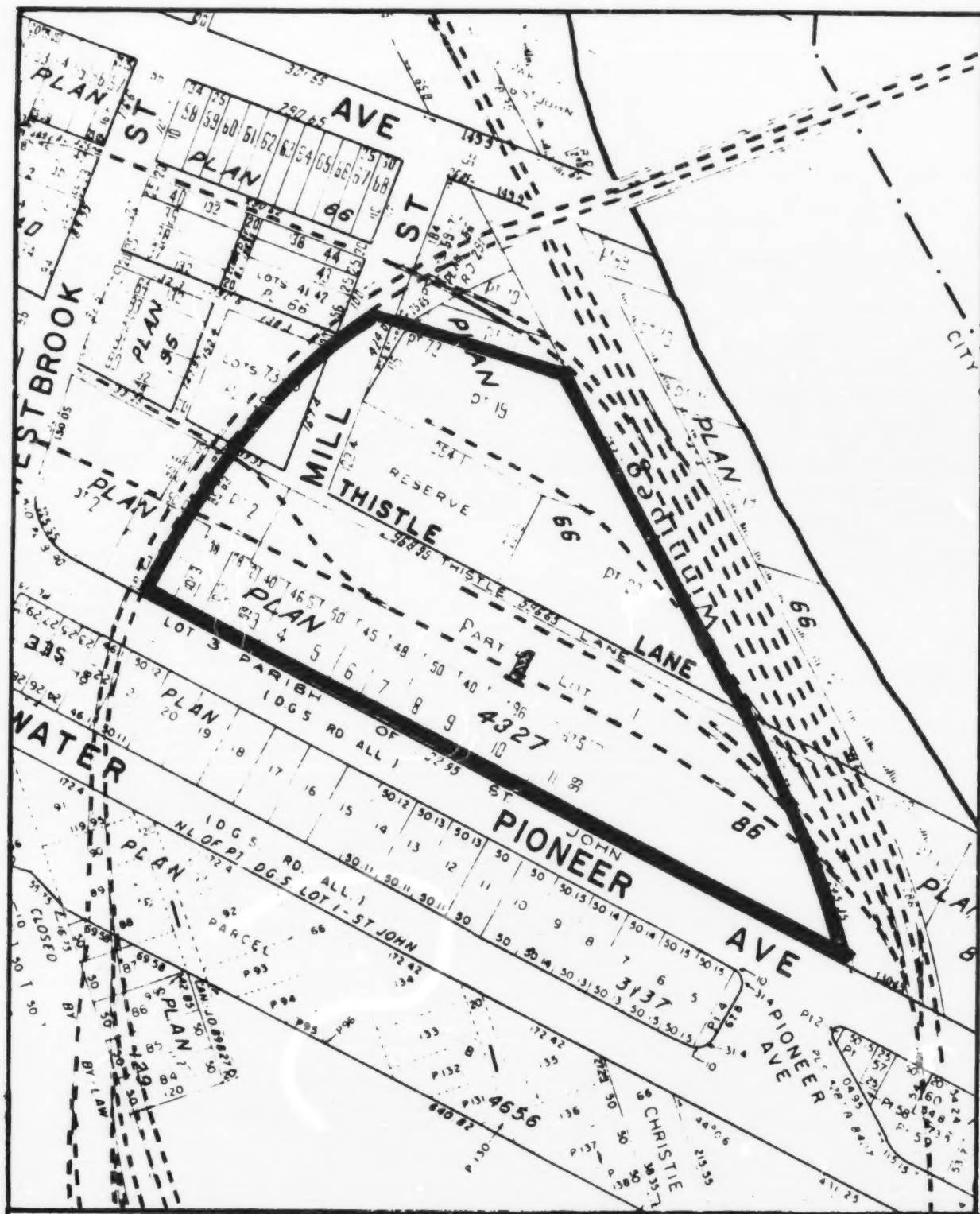
- Land costs
- Site development costs
- Plant costs
- Distribution system costs
- Environmental mitigation measures (i.e. stack height)
- Operating costs (present value)
- Haul costs (present value)

1.7.7 Selection Process

In some site selection studies, site dependent costs are "normalized" and added to environmental and public acceptance scorings to produce an overall score for each site. In other cases, the environmental/public acceptance scores are plotted against the site specific cost to produce a visual tool for comparing sites without actually combining "dollar" and "environmental" impacts. The second method was utilized in this Study.

A plot of environmental/public acceptance scores against site specific costs for the candidate sites is shown on Figure 1.12. The rationale for selection of preferred and alternate sites was as follows:

- Mill Street has the lowest cost, therefore consider Mill Street as a possibility;
- Mill Street has a lower cost and a lower site rating than Disraeli, therefore eliminate Disraeli;



CITY OF WINNIPEG - DISTRICT HEATING STUDY

PREFERRED PLANT SITE: MILL STREET



FIGURE 1.13

- . Grace Street has a slightly lower site rating than either Manitoba Bridge or Incinerator, and a lower cost, therefore eliminate Manitoba Bridge and Incinerator and consider Grace Street as a possibility;
- . Rue Messier has the lowest site rating, therefore consider Rue Messier as a possibility;
- . Both Mill Street and Grace Street have substantially lower costs than Rue Messier; also neither Mill Street nor Grace Street have exceptionally poor site scores and are roughly in the middle of the range of site scores; therefore eliminate Rue Messier;
- . Mill Street has a lower cost than Grace Street, therefore select Mill Street as a preferred site (see Fig. 1.13) and Grace Street as the alternate.

The site selection process does not require that the site with the lowest environmental/public acceptance score be chosen. Rather the process strikes a reasonable balance between environmental/public acceptability, and cost. On the basis of the environmental/public acceptance assessment and cost, the Study team considers that the Mill Street and Grace Street sites are acceptable as the preferred and alternate sites respectively.

1.8 ECONOMIC ANALYSIS

The purpose of the economic analysis of the project was to determine economic viability. Economic viability has been defined as the ability to generate sufficient revenues or savings to pay for the annual costs of operation and to carry and retire debt (and/or provide an acceptable return on equity) over the course of the project's life. The identified system is economically viable on this basis yielding a 5 percent real internal rate of return at the project level and greater than 10 percent at the City of Winnipeg level.

Review of financing and ownership scenarios indicated that the most likely scenario is one in which the system is owned by the City of Winnipeg, operated as a municipal utility and funded through municipal debt.

1.8.1 Methodology

A commercial approach to investment decision making has been used in the economic analysis. This approach incorporates a stratified analysis which measures cash inflows and outflows, or benefits and costs, on a number of levels.

This stratified analysis recognizes that unlike most assessments, benefits and costs do not all accrue to one party. Those potentially affected by this project include Winnipeg Hydro, all three levels of government and society at large. The stratified analysis considers only direct, identifiable, monetary impacts of the project on all levels.

The project level analysis considers only direct monetary costs and benefits associated with the construction and operation of the EFW plant and district heating system. It simulates the analysis of a private concern at-arm's-length from government, from waste suppliers and from energy customers.

The secondary analyses at the Winnipeg Hydro, City, Province, Federal and societal levels isolate identifiable monetary costs and benefits to these levels which occur as a result of this project.

The analyses provided three indicators of economic viability as follows:

- Net Present Value (NPV) - As the City of Winnipeg has indicated that their long term real cost of debt is 4%, this figure has been used for discounting to the base year (1983).
- Internal Rate of Return (IRR) - This can be defined as the discount rate which equates the present value of expected cash outflows with the present value of expected inflows at the starting date.
- Payback Period. This is the length of time required for the project to recover the initial investment.

The following steps have been undertaken in the assessment of economic viability:

- The elements of cash flow at the primary project level of analysis were identified.
- The elements of cash flow at all other strata of analysis (which are the direct and measurable result of the project) were identified.
- A cash flow economic model which reflects the relationships between all project elements was developed.
- Project returns (e.g. NPV, IRR, years to breakeven) for each scenario (ongoing throughout study) were calculated.

- . Sensitivity analyses on key project variables to determine how sensitive economic feasibility is to each variable (ongoing throughout study) were performed.
- . The project scenarios were modified and optimized throughout the study to reflect improvements in data as the study progressed.
- . The reactions of typical potential investors to project returns and likely sources of financing were determined.
- . The final economic analysis and illustrative financing results were prepared.
- . Conclusions on feasibility were developed.

1.8.2 Economics at Study Milestones

As various project scenarios were developed, their viability was assessed through economic analyses. These scenarios covered a broad range of possibilities in the early part of the project, but the focus narrowed as the project proceeded. At Milestones No. 1 and No. 2 in June and October 1983 respectively, project progress was presented including a review of economic viability of the scenarios considered to that point in time.

At Milestone No. 1 in June, a broad range of scenarios was used to "bracket" the problem under study. They included a small and a large market size, a small and a large plant size (3 x 400 t/d and 3 x 600 t/d) and two sites (one representing a remote site, Rue Messier, and one representing a downtown site, Disraeli). Internal rates of return varied from 2.6% to 6.2% in real terms at the project level. The following conclusions were drawn:

- . The project generated an economic surplus at the project level.

- Project economics were improved when the larger plant served the larger load (plant size and load matched waste volumes).
- The project was capital intensive and required approximately 15 years to breakeven at the project level following plant start-up.
- The project was most sensitive to the assumptions used for the F.I.R.E. (Forest Industry Renewable Energy Program of the Government of Canada) Grant, heat (steam) prices and capital costs.

At Milestone No. 2 in October, many study activities had resulted in generation of new data and estimated costs were improved. While some study areas remained incomplete, the level of confidence attributed to the analyses was significantly enhanced. Scenarios included three plant sizes (3 x 400 t/d, 3 x 500 t/d and 3 x 600 t/d), several potential sites, and a refined heat load falling midway between the small and large heat loads used in Milestone No. 1. Internal rates of return varied from 3.3% to 5.2% in real terms at the project level. The following conclusions were drawn:

- The project generated an economic surplus at the project level (IRR = 5.2% for 3 x 500 t/d plant at Mill Street site).
- A downtown site, Mill Street, had clear economic advantages over more remote sites because:
 - distribution system costs were reduced;
 - a higher pressure plant was required at remote sites to accommodate electrical generation using the Amy Street turbo-generators;
 - remote sites were further from the source of wastes and consequently haul costs were increased for these sites.
- A 3 x 500 t/d plant size provided the best economic return of those analyzed.

- The project was sensitive to heat prices, the F.I.R.E. Grant, capital costs and avoidance of electrical upgrade costs by Winnipeg Hydro. However, project returns were not radically affected by moderate changes in key variables.

As a result of Milestone No. 2 analyses, a 3 x 500 t/d plant located at a Mill Street site was recommended as the preferred scenario on which subsequent study activities would be focussed.

1.8.3 Final Economic Analysis

During the final stages of the study, all aspects of the study as they related to the preferred scenario (3 x 500 t/d plant located at the Mill Street site) were reviewed and estimates refined. The significant changes which resulted were:

- Steam revenue increased primarily due to pricing revisions.
- Capital costs increased due to refinements and inclusion of costs for peaking facilities at Amy Street.
- Operating costs increased to support the peaking plant change.

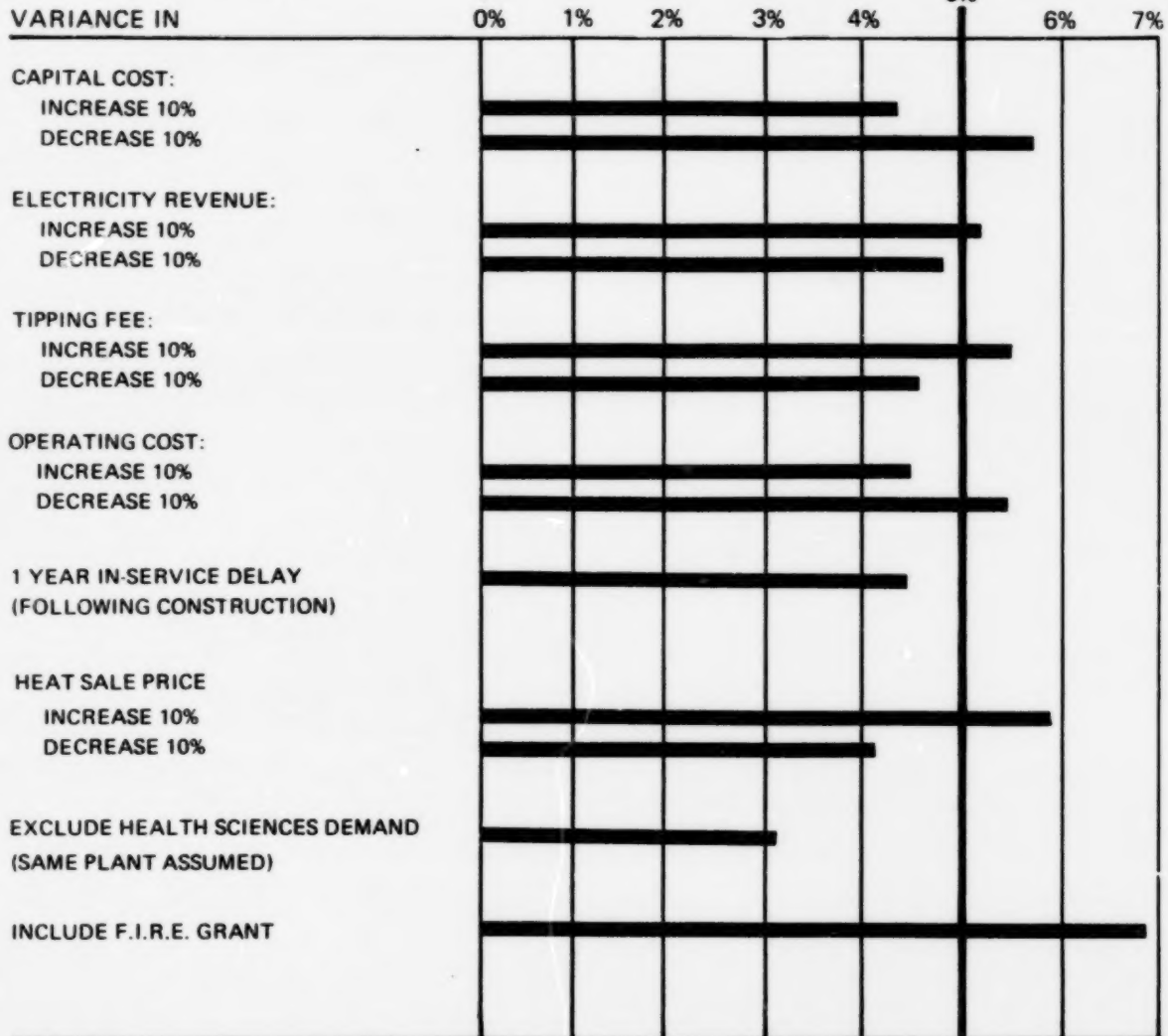
The refined data used in the final economic analysis has not caused any change to the conclusions drawn at Milestone No. 2. The results of the final analysis are highly comparable to previous analyses on the Mill Street 3 x 500 t/d configuration.

The conclusions are:

- The project is economically viable and provides an internal rate of return, in real terms, of approximately 5%.
- The rate of return generated by the project is sensitive to the F.I.R.E. Grant assumption. The inclusion of F.I.R.E. Grant funding to offset 20% of all eligible capital costs increases project level returns to approximately 6.9%.

PROJECT LEVEL IRR

BASIC
IRR
5%



- . The project's viability is sensitive to heat price assumptions. A 10% increase in steam prices charged, equates to a 18% variation in project IRR (5.0% to 5.9%).
- . Capital cost assumptions have the next greatest impact on project viability. A 10% increase in capital costs, say approximately \$10 million, causes project level IRR to decrease to 4.3%, a change of approximately 15%.
- . The economic viability of the Energy from Waste - District Heating System is significantly enhanced when the benefits attributed to Winnipeg Hydro are aggregated with the project benefits. The real internal rate of return at the Winnipeg Hydro level is projected to be 10.35%. This occurs because it has been forecast that without a District Heating System in place, Winnipeg Hydro will be required to undertake capital expenditures of approximately \$24 million before 1989. Therefore, Winnipeg Hydro has identified these avoided expenditures as a benefit from the project.
- . An analysis of the approximate impact of excluding the Health Sciences Centre demand from the "probable" total demand indicates that the project level IRR would decrease to 3.1% without the F.I.R.E. grant.

Sensitivity of project economics was tested and variance in IRR to changes in some key input variables are shown in Figure 1.14.

1.8.4 Project Financing and Ownership

The issues of financing and ownership have been assessed in the context of projected financial results for the project. Ownership options, financing options and projected economic results are necessarily interrelated.

Debt of the magnitude required for this project is potentially available from major financial institutions. Although lenders expressed an interest in this type of project, during interviews with them, they attached many strong caveats to their interest. Their main concerns were associated with:

- . the "uncommon" products and technology;
- . the illiquidity of the investment;
- . the necessity for public sector cooperation;
- . the possibility of raising public environmental/safety/aesthetic concerns.

All lenders mentioned that, because project returns are not high enough to justify the perceived risk, government commitments/guarantees would be key elements in the evaluation of a financing proposal.

While private sector financing of this project through debt and/or equity is conceptually possible, it is unlikely that private sector owners can be identified who would serve as active project proponents and who would assume the risk for project funding. Private sector funding would likely be available if the project risks were assumed by the public sector through financial guarantees.

If the public sector is to accept the project risks, the most economic method of accomplishing this is through direct public debt funding. While all levels of the public sector would be affected by this project, the most direct and immediate impact would be upon the City of Winnipeg.

1.8.5 Economic Viability - Scenario with Inflation Included

For illustrative purposes, an economic analysis was run for a municipally-owned and financed facility and under an assumption of 8% inflation and 12% interest over the project life.

All negative cash flows were assumed to be covered by bond issues with a 30-year maturity, a bond issuance cost of 1% of each issue was charged against the project.

The analysis was carried out at the project level without taking into consideration costs which would be incurred if the project did not proceed. The major item not included is the \$24 million capital expenditure required of Winnipeg Hydro.

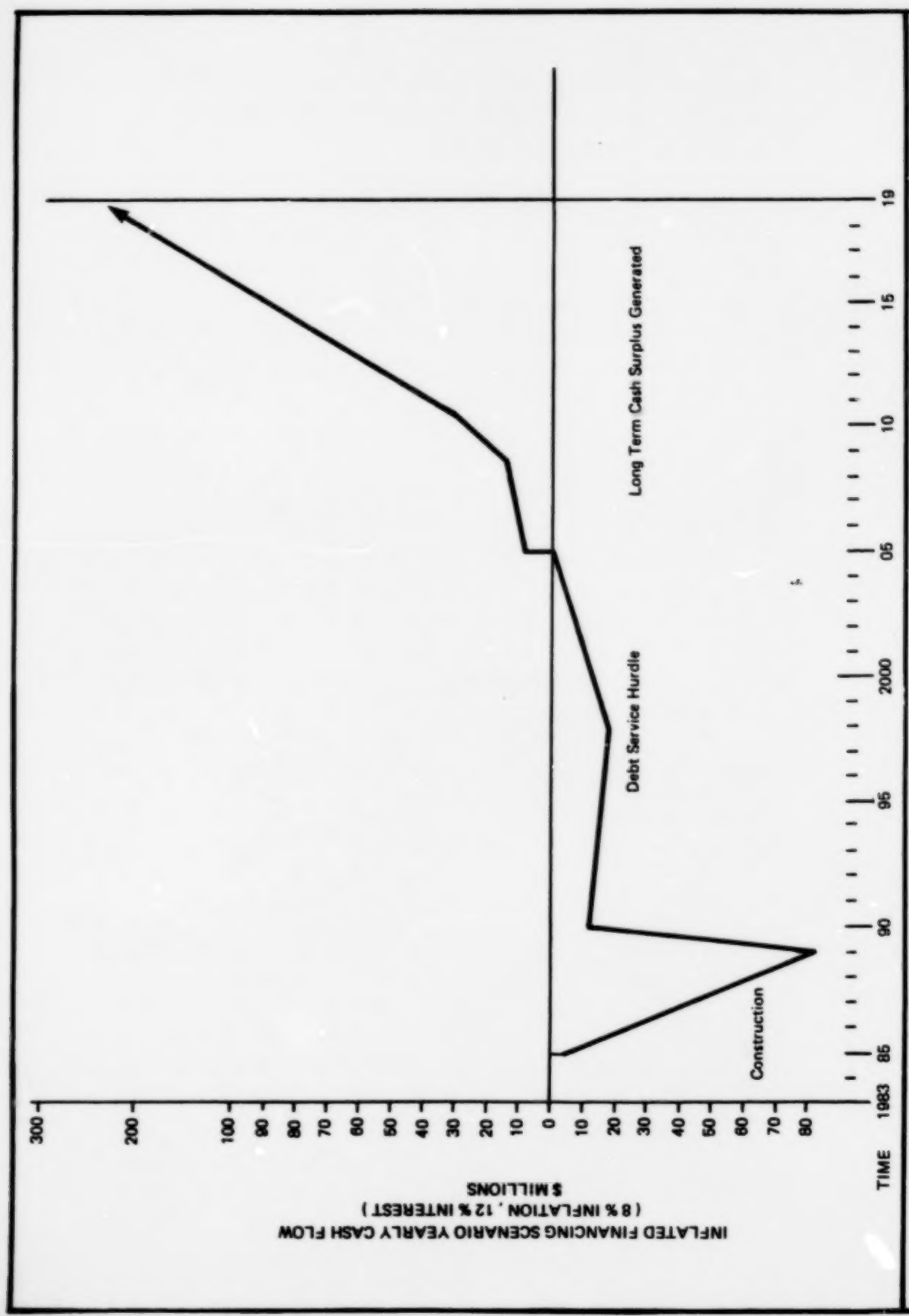
Thus, the following results represent total rather than incremental costs.

The analysis showed that construction costs, in inflated dollars and including interest during construction, would be approximately \$180 million. Total debt outstanding, in inflated dollars, will peak approximately 13 years after plant opening at \$300 million. The facility will fully pay for itself after 25 years of operation and have more than 1 billion inflated dollars on hand at the end of the 30-year operating period. The project cash flow for this scenario is illustrated in Figure 1.15 and outlined on Table 1.7.

It should be emphasized that this scenario assumes continuous inflation of 8%, and the City's actual cost of borrowing at 12% for every year until the year 2019.

More moderate assumptions of inflation and interest costs, and consideration of avoided costs would result in significantly different numbers being produced.

The results of the illustrative financing model support the conclusions on economic viability. The project provides positive economic returns but requires a long term commitment to realize these returns. The facility would appear viable as a municipal entity if the funding necessary in the key years from 1987-1989 can be accommodated by the City's capital budget.



CITY OF WINNIPEG — DISTRICT HEATING STUDY
YEARLY PROJECT LEVEL CASH FLOWS

FIGURE 1.15

1.9 IMPLEMENTATION PLAN

This section outlines the key considerations associated with the implementation of an Energy From Waste - District Heating System for The City of Winnipeg.

The plan begins at the conclusion of this feasibility study and continues through to project completion and operation. Because many aspects of the implementation process can only be determined subsequent to decisions which will be made by The City of Winnipeg, the plan accommodates two implementation routes. One route is that which will be required if The City of Winnipeg decides to proceed with public ownership of the project. The second route is that which will be required to pursue private ownership and financing of the project.

The implementation process has been broken down into the following stages:

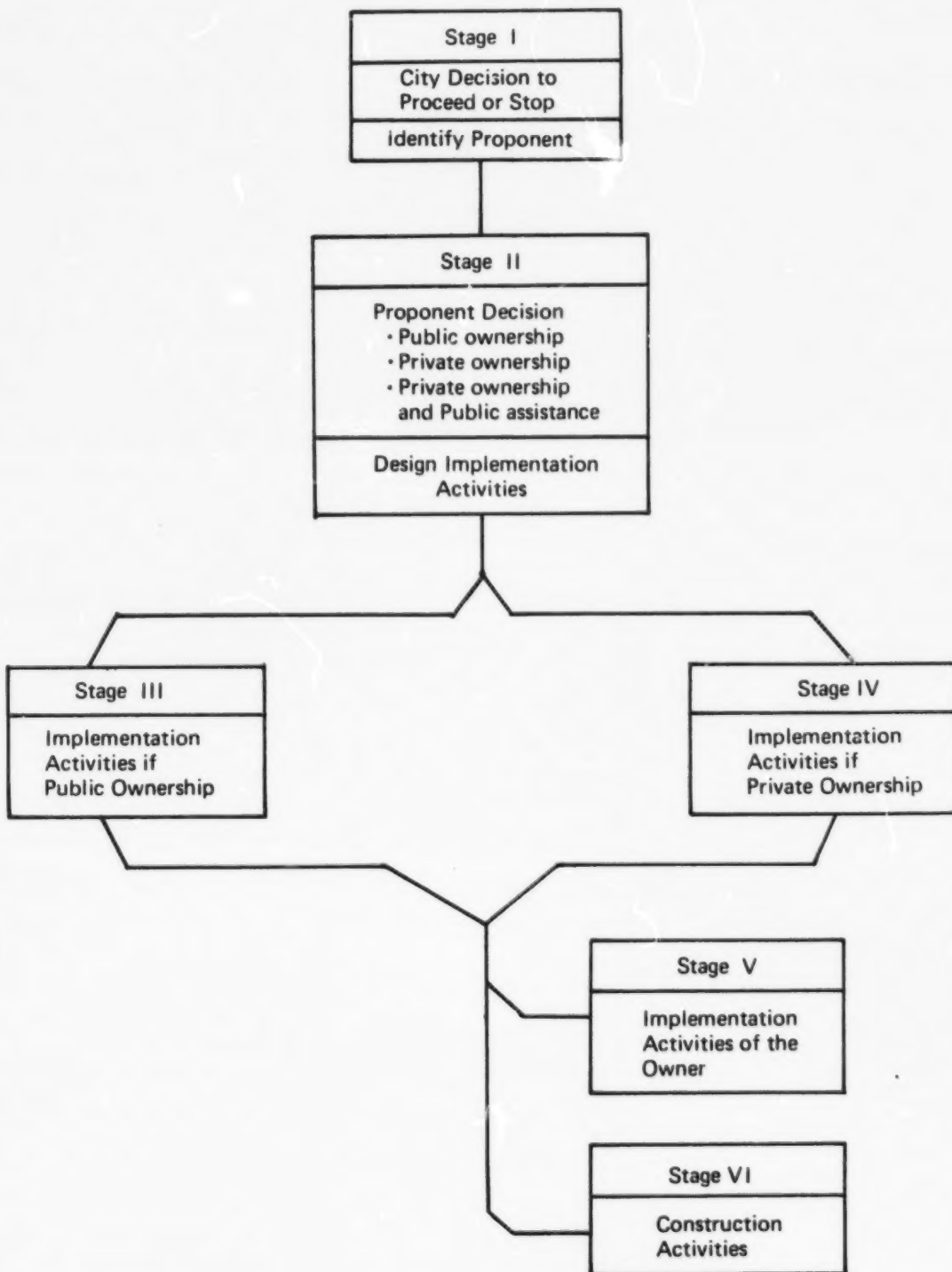
Stage I - City of Winnipeg Decision and the Identification of a Proponent

Stage II - Proponent Selection of an Ownership Structure and the Design of a Corresponding Implementation Effort (Public or Private Ownership)

Stage III - Proponent Implementation Activities if Public Ownership Selected

Stage IV - Proponent Implementation Activities if Private Ownership Selected

Stage V - Implementation Activities of the Owner (Public or Private) Once the Final Decision to Construct is Made



CITY OF WINNIPEG - DISTRICT HEAT STUDY
ENERGY FROM WASTE
IMPLEMENTATION PLAN STAGES

FIGURE 1.16

Stage VI - Construction Activities

The inter-relationship between these stages is shown on Figure 1.16.

1.9.1 Stage I - City of Winnipeg Decision and the Identification of a Proponent

The future of this project will be molded very early by the decisions made by The City of Winnipeg. The City decision will conceptually fall into one of the following categories:

- a) reject further EFW implementation;
- b) proceed with implementation efforts contingent upon senior government participation;
- c) proceed with implementation efforts.

Should the decision to proceed be made, either by the City or in conjunction with senior governments, the clear identification of the implementation Proponent will be a clear requirement. The Proponent will guide, control and fund on-going implementation assessments and activities. The Proponent could be the Executive Policy Committee - City of Winnipeg or may include senior government decision makers, depending upon the options selected.

1.9.2 Stage II - Proponent Selection of an Ownership Structure and the Design of a Corresponding Implementation Effort

The Proponent will determine the nature of the implementation activities required by making a fundamental decision regarding how the EFW facility should be owned and financed. The broad conceptual range of ownership and financing options from which the Proponent will select includes:

- A) Public (the Proponent) ownership and financing.
- B) Private ownership and financing with no direct risk accepted by the Proponent. Here the Proponent will undertake a number of implementation activities to facilitate finding a private sector owner but will accept no direct involvement in the funding required to make the facility financially acceptable to the private sector.
- C) Private ownership and financing with the Proponent accepting the financial risk (some or all) should the EFW-District Heating System prove uneconomic to the private sector owners. This assumption of risk by the Proponent could take a number of forms. For example, the Proponent could guarantee the debt of the private sector owner. For another example, the Proponent could guarantee to lease the EFW facility from the private sector owner on a long term basis to ensure the private sector owner of an adequate return on investment.

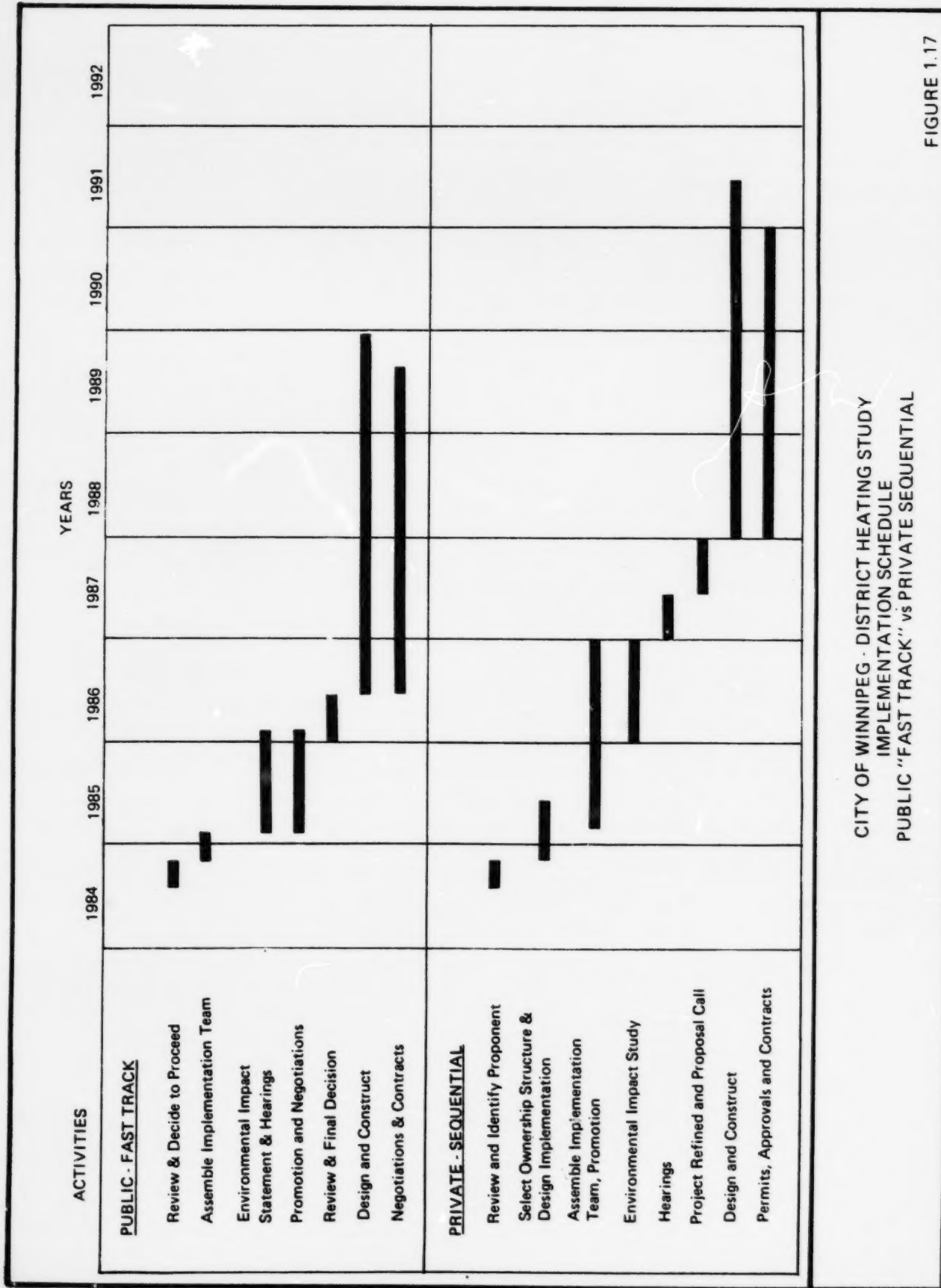
The decisions required in Stage I and Stage II are closely interrelated and may proceed simultaneously or on an "iterative" basis.

Having decided conceptually how the project's ownership, financing and risk will be allocated between the public and private sectors, the Proponent will create a committee with the mandate to design the detailed implementation effort and corresponding budget. The Proponent will review and accept, modify or reject the implementation effort and budget.

1.9.3 Stage III - Proponent Implementation Activities If Public
Ownership Selected

If the Proponent has directed the implementation committee to develop a facility owned by the Proponent (the Public), the following activities will be essential:

- . Assemble an implementation team - the committee will need to identify and obtain staffing and financing resources to carry out the implementation activities which will be required.
- . Research, promotion and preliminary negotiations - the implementation team will undertake a variety of research tasks to identify legal issues, precedents, bond market data and the contractual experiences of other energy recovery facilities. Promotion will be necessary to keep both potential customers and the general public aware of developments. Negotiations will be initiated with major heat loads to obtain a "letter of intent" to connect to the new District Heating System upon commencement of operations.
- . Environmental impact study - it will be very important for the Proponent to commence work on a complete Environmental Impact Study (EIS) early in the implementation process. This will be important for several reasons. First, the proponent will require the information from the EIS prior to the final decision to build the facility. The EIS will directly and openly address the numerous concerns of the citizenry regarding the environment, land use, etc. Second, the EIS will be a critical path item requiring approximately one year to complete.



CITY OF WINNIPEG - DISTRICT HEATING STUDY
IMPLEMENTATION SCHEDULE
PUBLIC "FAST TRACK" vs PRIVATE SEQUENTIAL

FIGURE 1.17

- Update economics and refine project - the Proponent's implementation team will continually update its assessment of markets, of its ability to adhere to environmental guidelines and of overall economics as additional information is developed.
- Final decision to build or stop - the Proponent will reach a final decision point to construct or to discontinue in approximately 2 to 3 years from the commencement of implementation activities. The actual length of the implementation period will be largely determined by the resources available to the implementation team and by the length of time taken by the Proponent for review, deliberation and decision making. This Public "Fast-Track" Scenario is illustrated in Figure 1.17.

1.9.4 Stage IV - Proponent Implementation Activities If Private Ownership Selected

If the Proponent decides to pursue private ownership of the EFW facility, many of the activities of the implementation team would be similar to those discussed as Stage III activities and could be repeated here.

Stage IV differs from Stage III through its emphasis on the identification of and negotiations with private sector owner/ investors. The premise upon which Stage IV has been designed is that the Proponent will incur a number of implementation costs to give the project its best chance of proceeding.

Stage IV activities will be essential whether the Proponent has mandated full private ownership and financing or whether the Proponent has determined that the public sector will assume some element of project risk (through guarantees, etc.). The eventual construction of the EFW facility under the private ownership assumption is entirely contingent upon the success of Stage IV activities which are aimed at negotiating an acceptable deal with a private sector owner.

The final construct decision (joint decision by the Proponent and the private owner/financier) may realistically be arrived at approximately 2 1/2 to 3 years from the commencement of implementation activities. This process will be additionally complex under a private owner assumption and may encounter additional delays in negotiation. Furthermore, it is likely that fewer implementation activities can proceed in parallel under a private owner if he wishes to assess all data before making a final commitment. This will limit the ability to compress the implementation timetable. This expanded schedule is shown in Figure 1.17.

1.9.5 Stage V - Implementation Activities of the Owner (Public or Private) Once the Final Decision to Construct is Made

Once the decision to construct the EFW facility is made, either by the Proponent (Stage III) or by the private sector (Stage IV), the activities required by the owner mirror those for any large construction project.

Some of the more noteworthy include:

- . Decision on engineering and construction process:
 - i) design and tender individual packages;
 - ii) tender the entire facility to one consortium while retaining an independent consultant to monitor construction;
 - iii) tender a full "turnkey" facility.
- . Full promotion of the facility - the owner will undertake an extensive promotional effort to develop and guarantee a heat load for the date of the plant opening, approximately 3 1/2 years after the construction decision is made.
- . Operations - the owner will determine how the facility will be operated when fully constructed.

1.9.6 Stage VI - Construction Activities

The complete construction schedule is estimated to require approximately 42 months. The most time critical of these activities will be the fabrication, erection and testing of the incinerator package which is estimated to require approximately 30 months.

1.9.7 Summary

The key implementation considerations can be summarized as follows:

- . The project will clearly require an implementation Proponent. This Proponent may be The City of Winnipeg or may comprise civic plus senior government interests;
- . The Proponent can elect to pursue public or private ownership. It has been recommended in this report that public ownership be viewed as the scenario most likely to achieve success;
- . The implementation period prior to a construction decision will likely cover 2 to 3 years. The actual time required will reflect the resources of the implementation team and the timeliness with which the Proponent addresses necessary decisions;
- . The construction period itself will require approximately 3 1/2 years.

An illustrative Implementation Schedule comparing the Public "Fast-Track" scenario to the Private Sequential scenario is shown in Figure 1.17.

It is important to note that project economics will not be greatly influenced by delays in the front end of the implementation schedule prior to large commitments of capital. However, once construction has commenced and capital has been committed, delays in completing the project and commencement of revenue flows will adversely affect economics.